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WORLD CROPS

The International Journal of Agriculture

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WORLD CROPS

Editor: Frank Cooke, A.R.C.S., B.SC., A.M.I.CHEM.E., E.D.

Vol. 9, No. 7 — JULY 1957

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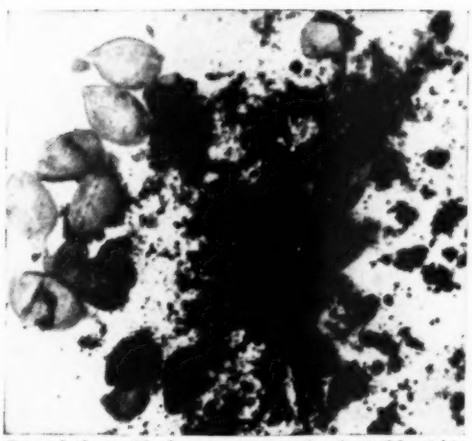

Bunted wheat. Black spore masses clearly visible within the grain.

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WHEAT	Bunt	**MAIZE**	Dry rot
BARLEY	Covered smut · Leaf stripe · Net blotch	**SORGHUM**	Kernel smut Leaf spot
RYE	Bunt · Stripe smut	**GROUND-NUTS**	Black rot Foot rot
OATS	Covered & loose smuts Leaf stripe	**JUTE**	Stem rot
RICE	Foot rot · Leaf spot	**SUGAR BEET**	Black leg

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Editorial Comment

The British Association

THE British Association for the Advancement of Science remains unique as an independent institution of international reputation, which brings almost the whole range of science within its scope and opens its membership to all interested in the progress of science. Founded in 1831 to convince an indifferent public and government that science was important and worth backing, the Association has succeeded magnificently in its original purposes. Today science is of paramount importance to the community and one of the Association's main tasks is to promote a better understanding of its impact, through its applications, on society and the world as a whole.

The continuance of science is vital to modern society and, this being so, continued public goodwill and understanding are essential. To ensure this, the methods and results of science and the nature of fundamental research must be better understood by those concerned with government, industry and business and the world at large. Such understanding is essential because an informed public is necessary if valid decisions are to be taken; because the public—as taxpayer and consumer—pays for science; because if, in the future, scientists and technologists are to be forthcoming in the numbers that the world requires, the public should learn to value the contribution of science and come to appreciate the potential satisfaction and opportunity for service implicit in careers devoted to science; and, above all, because scientific discovery must be applied for the well-being of the nation and of the world.

The Association's main contribution to this end lies in its great annual meetings, which are attended by representatives from every branch of science; by industrialists, by government servants, by agriculturists and by those directly interested and involved in the applications of science in Britain and in countries overseas; by teachers, representatives of the press, radio and television; by laymen interested in the progress of science and its social implications; and by visitors from abroad.

The meeting, broadly speaking, attempts to do three things. First, to offer a platform on which leading scientists can discuss their work in all its complexity—for fundamental work is not only at the heart of all progress in science, but it is also important to demonstrate the 'compulsion of facts' and the 'dignity of expertness' and to give the public an understanding of the integrity and discipline involved in the search for scientific truth. Secondly—for such is the specialisation and fragmentation of science—to encourage scientists to discuss in joint sessions problems in related fields and to develop common problems involved in subjects on the frontiers of present knowledge. For if communication between scientists is limited, the advance of science is retarded; and new outlooks and avenues of enquiry may emerge from such juxtaposition of the work of different specialists. Thirdly, to provide for non-specialists—whether they be scientists outside their own field or interested laymen—an annual stocktaking in intelligible language which will review the progress of science and help to make clear its significance and possible consequences to the world.

Plenty comes

PRODUCTION gains valued at almost $U.S.68 million have been reported by 17 European and Mediterranean countries as a result of their use of hybrid maize varieties in 1955. The report of the Ninth FAO Hybrid Maize Meeting said that the increase of some 845,000 tons was achieved, although only 9% of the total maize-growing areas of the participating countries was sown to hybrid varieties. It is clear that a tremendous increase in food and feed will follow when these countries increase their 'hybrid' acreage to 25, 50 or 75% of their total maize area.

A number of delegates attending the 28th Session of the Committee on Commodity Problems expressed concern about current sales of agricultural surpluses on world markets and apprehension about the possible future effects of surplus transactions. Other delegates, however, said they did not think there was serious cause for alarm.

Mr. F. M. Tromp, South African delegate, said there was some apprehension in South Africa about the effects of surplus disposals on South African exports of maize. If the FAO principles of surplus disposal were not fully observed and competition developed between governments to subsidise maize exports the South African farmer could not hope to compete.

Dr. S. R. Sen, delegate for India, told the Committee that the agreement under which India was receiving surpluses from the U.S.A. contained detailed precautions to ensure that the special transactions would not unduly disrupt world prices or materially interfere with normal trade patterns, and, in fact, India's wheat imports from other countries had risen since the agreement was signed last year.

The Brazilian delegate, Mr. A. de Viana, assured the Committee that the recent Brazil–U.S. agreement for surplus wheat fully safeguarded the position of traditional suppliers of wheat to Brazil, as purchases from the U.S.A. were supplementing, and not displacing, normal imports.

The New Zealand delegate, Mr. F. B. Prendergast, said his country was very apprehensive about the surplus situation. After three years in which they had been a problem the extent of surplus stocks had hardly changed and there was a widening range of methods being devised for disposing of surpluses which made it difficult to keep track of transactions or exercise any control over them.

The Canadian delegate, Mr. S. C. Hudson, said that his country's wheat exports had been seriously affected by surplus disposal programmes. His Government's view was that sales of surpluses on concessional terms should be made only to under-developed countries and for only two purposes: for building up national reserves against emergency and for financing economic development leading to increased consumption.

Mr. F. W. Bulcock, delegate for Australia, said he believed that, unless nature intervened to reduce agricultural production, the surplus situation was going to be more, rather than less, serious.

Mr. R. H. Roberts, leader of the U.S. delegation, said the U.S.A. appreciated the apprehension of other governments over surplus disposals by the U.S.A. and by other governments. The U.S.A. had been extremely careful in its disposal programmes to avoid harming friendly countries and its policies were based on two other principles: (1) making the most effective use of the surplus products in increasing consumption of poorer peoples, and (2) preventing the accumulation of further surplus stocks. The U.S.A. had high hopes that its Soil Bank programme, which was just beginning to come into effect, would reduce the country's surplus stocks and prevent future accumulations.

Cereal varieties

NO student of British agriculture could deny that our cereal cropping has been revolutionised by modern varieties, notably in fairly recent years by the lodging-resistant, strong-strawed varieties. The wider use of fertilisers, especially of nitrogen, has also raised average yields steadily, but this cannot be regarded as a separate development—on many farms nitrogen rates have been raised because these new varieties stand better even with a heavier load of grain in adverse pre-harvest weather. But information about the extent to which these varieties are, in fact, taking their place in British farming has been scarce. Seed merchants' figures show part of the trend, but such data are not openly published. Economic surveys by university research workers seldom cover such crop details as variety. A paper by B. M. Church, of Rothamsted, in the *Journal of the Institute of Agricultural Botany* (1956, 7, 474) reporting a cereal variety survey for England and Wales for 1952–54 is therefore exceptionally welcome, despite the fact that further changes in variety preference have already occurred since 1954.

This national survey, based upon 29 district surveys, showed that 78% of the winter wheat sown in England and Wales was of the 'good standing power' kind, with Hybrid 46 showing a 23% share and Bersee and Cappelle each holding 11%. Cappelle has undoubtedly made more headway since. As for spring wheat, Atle (70%) and Fylgia (22%) dominated the field. But a disconcerting aspect of the wheat survey figures is that in the wetter districts, where, above all, the lodging-resistant varieties should have been welcomed, older varieties that have poorer standing power were in 1952–54 still holding high shares of the wheat acreage. Thus in the south-west, for surveys covering parts of Dorset, Devon, Somerset and Cornwall, 59% of the winter wheat sown was *not* of the strong-strawed class; the percentage of Hybrid 46 sown was as low as 8, Cappelle was unrecorded in the surveys, and only Bersee redeemed the general picture by showing a 15% share. In Monmouth, another wettish area, 44% of the wheat surveyed was of older and poorer standing-power kinds. Here once again there is an indication that technical advances are made at the slowest pace where they would, in fact, bring the greatest benefits.

The barley variety survey data seem of small value. 1952–54 was not a good period to strike for this branch of cereal cropping, for Proctor has made such widespread advances since then. Only three districts in 1952–54 recorded crops of Proctor and the overall percentage was as small as 1%. Spratt-Archer with 27% dominated the 1952–54 picture for spring barley, and Pioneer at 66% dominated the winter barley picture even more heavily.

As for oats, the spring crop was almost two-thirds accounted for by Onward, Star, Victory and Sun II, and the winter crop practically monopolised by S.147 at 59% and S.172 at 34%.

Even if the position of cereal varieties is still fluid, with popularity ratings rising and falling almost like those of film stars, the veteran agriculturist can only look at these 1952–54 figures and reflect how the mighty have fallen—Holdfast, Yeoman, Little Joss, Squarehead's Master among the wheats; Chevalier and Prentice among the barleys; and Grey Winter oats. In this matter British farmers in most districts have certainly been progressive rather than conservative.

A master of damage

THE rat has always managed to inspire a particularly violent revulsion to its presence. Through disease and famine it has earned an evil reputation as a threat to man's well-being.

Few areas of the world are free from the scourge and in many countries they are a serious national menace. The Philippines is one of them. Field rats infest many parts of the country, but the most serious infestation occurs in parts of Mindanao Island in the south. There are no reliable statistics of the density

of the rat population, or even of the damage they cause, but in some of the more serious outbreaks farmers have lost up to 80% of their entire crops. These constant losses are a serious problem in a country which is still importing food.

A short while ago the Government of the Philippines asked FAO for advice in carrying out a field rodent control programme in Mindanao and last June Mr. R. J. Clarke, of the U.K., arrived in Manila to begin work on this project. He spent the first three weeks of his assignment interviewing officials of the various departments concerned with rodent control and speaking to a number of private firms dealing in bacterial rodenticides. He learned that the bacterial method of control had been confined to rat control in urban areas, farm buildings etc. Field rats, inhabiting the long grasses and dense vegetation, present a much more difficult problem. Experiments will have to be made with a full application of all known methods of control before any recommendations for permanent control can be made. One of this expert's first problems will be to obtain a reliable estimate of the density of the population. At present such estimates are usually done by 'blanketing', by which a team of workers cuts down the vegetation in a given control area and counts the rats killed or seen. This method needs to be checked for reliability and it is also relatively expensive. Mr. Clarke proposes to obtain a more accurate estimate by 'census baiting', which is a means of estimating the number of rats present in a given area from the amount of carefully distributed food which they consume.

Soil fertility

WE have received a letter from Mr. A. C. Edmonds, a farmer in Southern Rhodesia, asking for more articles on soil improvement. We were able to point out that no less than nine articles which either deal directly with or else touch on this important subject have appeared during the first six months of this year.

The most important development is, we consider, the use of the aeroplane for the improvement of 'badlands' by the aerial spraying of major fertilisers, the necessary trace elements and mixed pasture seed. *In this work New Zealand is leading the world.*

H_2S in submerged rice soils

HYDROGEN sulphide is toxic to plants; it causes injury to root cells and inhibits respiration. Workers in Japan have concluded that the severe *Helminthsporium* root rot in rice growing in certain soils was a result of H_2S injury.

The sulphides are the reduction products of sulphates brought about by anaerobic bacteria at high pH, the applied fertilisers ammonium sulphate, super and potassium sulphate being the chief sources of the sulphate. The conditions obtaining in a submerged paddy soil containing considerable amounts of easily decomposible organic matter are ideal for such anaerobic decomposition.

The formation of H_2S in paddy soils and its effects on the crop have recently been studied by Natarajan, Seshagiri Rao and Mariakulandai at the A.R.I. at Coimbatore in South India. They concluded that only in soils highly deficient in iron does the formation of this toxic gas present a serious problem.

Foliar feeding

THE *Rose Annual for* 1957, issued by the National Rose Society of Great Britain, contains two interesting references to this subject. Although the fact has long been known to science that the leaves of plants can absorb food substances, it was not until 1922 that commercial use was made of the fact, in connection with the spraying of lettuce and cauliflower. Today special fertiliser mixtures are on the market (*e.g.* RA-PID-GRO and NUGreen) for spraying leaves with the object of foliar feeding.

Potash, used in this manner, tones and brightens up the leaves of rose bushes, nitrogen acts quickly, and manganese, magnesium and iron salts rapidly overcome chlorosis. With foliar feeding the soil and the plant roots are short circuited and a moribund plant may benefit markedly thereby. The mixtures now available contain N, P and K, trace elements and hormones. The nitrogen is often present in the form of urea.

Great success has been recorded with foliar feeding on roses growing in strongly alkaline soils, which fix or render non-available much of the plant food. The best results come when young leaves are treated, and the most satisfactory time to spray is apparently in the early morning.

It is a far cry from an English rose garden to an Assam tea plantation, where spraying trials with sulphate of ammonia were recently carried out. Concentrations ranging from 0.1 % to 5 % of the fertiliser were used, but solutions stronger than 1 % injured the leaves.

An instance of the foliar feeding of the tea plant in Eastern Africa is also worthy of mention. A certain area of about 200 acres produced leaf which failed to ferment on rolling. The so-called fermentation process in the manufacture of black tea consists mainly in the oxidation of the leaf polyphenols, which afterwards condense to form the substances responsible for the strength, briskness and colour of tea liquors. The oxidation is brought about with the aid of a leaf enzyme which is a copper-protein compound. The tea in question was devoid of this enzyme and additions of copper salts to the soil failed to put matters right, perhaps because the copper was fixed in the soil. However, when the tea bushes were sprayed with Bordeaux mixture (containing copper sulphate and lime) within three days the leaf fermented satisfactorily

and one spraying was found to suffice for about two years.

The copper content of tea leaf varies widely. In Nyasaland it is about 12 parts per million parts dry leaf, whilst in Ceylon it is double that figure. Thus a crop of 1,000 lb. of tea will remove from the soil less than ½ oz. of copper. Odd tea bushes, producing leaf which fails to ferment, have been found in Ceylon and in India, but whether this is due to a copper deficiency in the particular bush or to a shortage of or non-availability of copper in the soil has not yet been determined.

Sealed silage

RECENTLY (WORLD CROPS, 1957, 9, 179) we reported the use of black polythene sheeting for mulching tomatoes. We have since come across a report of another and perhaps more important use of this material.

Trials at Purdue University, U.S.A., have shown that this same type of polythene sheeting can be used as a kind of envelope-silo to provide airtight (anaerobic) conditions for making silage from fresh green fodder. This new method of silage-making has the great advantage that it need not be restricted to any particular site on the farm, as is the above-ground concrete silo or as the laboriously dug pit tends to be. The silage can be polythene encased at any suitable spot, near the cut crop or convenient for the winter feeding of the cattle at a later date.

The tests at Purdue University have shown that high-quality silage can be made in this way at a much lower cost than by conventional methods. The site, where the silage is held in polythene, should be fenced in to prevent farm or other animals intruding and making tears in the sheeting; if any small tears do occur, they can be repaired easily with pressure-adhesive tape. This could be a major development for silage progress; far more spring and summer foliage growth should be preserved for winter feeding as silage and simpler and cheaper methods of production would undoubtedly be welcomed on many farms.

Atomic energy and agriculture

ACCORDING to FAO, several European countries are working on the application of nuclear energy to agriculture. Norway is studying the use of atomic radiations for lengthening the storage time of fruits and vegetables; Sweden is working on plant mutations; in Denmark research is being done on the utilisation of radioactive isotopes as tracers in the study of agricultural problems; and Germany is giving attention to meat conservation using radiation.

On a proposal made by the U.S. Government, a centre for the comprehensive study of the application of atomic energy to agriculture is to be established in Costa Rica. It is considered that the Inter-American Institute of Agricultural Sciences is in a unique position to serve as a centre for research and training of technicians of the Latin American countries. The Administrative Committee of the Institute is considering how the funds necessary for the provision of the required facilities can be raised.

Hormones for coconuts

FROM India comes the news of the successful application of hormones to the flowers of the coconut palm.

Normally the palm produces these growth-promoting substances within the plant, but sometimes the supply of hormones is inadequate and exceptional 'button-fall', or loss of small nuts, occurs owing to the premature shedding of the female flowers within about two months of fertilisation. This loss has been evaluated at abuot 75% of the fertilised female flowers which would otherwise have matured into fruits, *i.e.* coconuts.

It is necessary to distinguish between the loss of half-formed nuts as a result of a period of drought and the shedding of baby nuts, which is Nature's safeguard against over-production and the exhaustion of the tree from over-bearing. Sometimes, however, this shedding of button-nuts can be excessive. This is attributed by S. R. Gangolly and T. P. Gopalkrishnan, of the C.R.S. Kasaragod in South India, to a cessation of the flow of hormones to the flowers. This led them to apply sprays of artificial hormones, some of which were successful in increasing the yields of nuts and copra.

The best time for spraying was found by them to be just after the completion of fertilisation, and the desired responses were obtained by four applications at intervals of seven days. The best result, a 70% increase in copra, was obtained with 2,4-D applied with an equal amount of coconut water; the strength of the hormone solution used was 60 p.p.m.

The skilled climbers used in this work have, of course, to be specially trained and closely supervised, but this is already being done where palms are artificially pollinated. Obviously, however, the method could only be used where there is a high standard of estate management.

Commonwealth research

IN our March issue (WORLD CROPS, 1957, 9, 91), the last paragraph of the item under this heading did not accurately present the recommendations of the Advisory Council on Scientific Policy. The Institute which is proposed by the Council as a clearing house and communication centre for tropical agricultural problems should be sited in the U.K. and not 'in some suitable tropical area' as stated.

WHEAT QUALITY

E. N. GREER

(*The Research Association of British Flour Millers*)

By courtesy of Henry Simon Ltd.

General view of the roller floor of a modern flour mill

In a previous article (WORLD CROPS, 1957, **9**, 98) *the agricultural aspect of the question of quality of wheat was discussed. The present article deals more particularly with the utilisation of wheat for different purposes and the specification of the type of wheat required for each.*

ANY discussion of the choice of wheat for food manufacturing purposes, and hence of wheat quality in this sense, requires as an introduction some statement of the reasons for the very widespread use of this cereal as a direct source of human food.

Apart from the fact that wheat is an accommodating crop and is widely available, one may further hazard the opinion that there are two main reasons for its popularity. (1) Ground wheat, when made into dough with water, produces a paste which possesses the property of elasticity as well as plasticity. Because wheat flour dough is to this extent elastic it can be aerated and cooked to make products such as bread and cake, which are 'light' in the cookery book sense. These physical properties of wheat dough are usually ascribed to the nature of the protein complex which is a part of the endosperm of wheat seed. Since the protein of wheat is itself known to vary in content and nature, according to the environment of the crop and the variety of the seed, it is obvious that on this score alone there is one count on which wheat quality can be judged. (2) The seed coat of wheat is sufficiently tough and the endosperm sufficiently friable for a practically complete separation to be made despite the awkwardly creased shape of the grain.

The importance of this lies in the fact that dough from the separated endosperm of wheat has better rheological* properties than the ground whole grain and that its flavour is slight and unobtrusive. This is of great importance, since it means that flour from wheat endosperm can be used in combination with an endless number of other foods and flavourings, and that bread made from white flour can similarly be eaten in association with a large number of other prepared foods.

If the separation of wheat endosperm from its seed coat is thus of importance, a second factor in quality becomes the relative ease with which separation can be made and the yield of flour (endosperm) which can be obtained.

Since wheats vary in size, weight and hardness, there is again an obvious choice from which specification as to quality can be made.

There are thus two main criteria for wheat quality which may well be entirely independent of each other, and it may accordingly be impossible to select a single wheat as being superior to all others in its manufacturing quality.

Wheat flour foods

It has already been said that wheat flour can be used in the making of a variety of foods. A short and inadequate list of the main types prepared commercially is shown in Table 1, where the percentage of water in the product, as it is sold, is indicated and the likely average wheat flour content of the dry matter.

Though average figures are given, which in the case of cake and biscuits may be subject to wide variation, and though, in these two cases, flour may be blended with large percentages of sugar and fat, the range of conditions among these different foods is suf-

*Rheology : The science of the flow of viscous fluids.

Table 1
Wheat flour foods

Type	*Moisture content, %*	*Flour as % dry matter*
Bread ..	44*	98
Cake ..	20	25
Macaroni ..	10	98
Biscuit ..	3–5	50

*Moisture content of crumb of freshly prepared British bread. Whole loaf moisture is 37%.

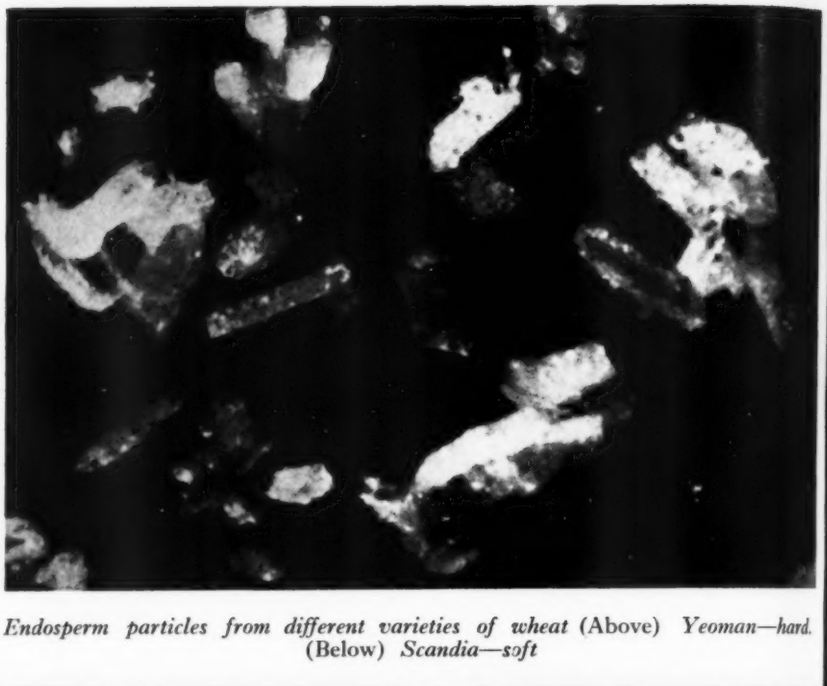
ficient to suggest that a single wheat flour is unlikely to be the best choice for all of them. There are thus likely to exist more criteria of wheat quality, which leads to the conclusion that this term can only have a precise meaning when the purpose for which wheat is to be used is specified. One may go further and point out that, though flour foods of the types mentioned are eaten in many countries, the methods of preparation vary, as does the type of finished article, which may mean that not only purpose but also process by which wheat is used is necessary for the complete definition of quality.

For the sake of simplicity it is worth while to discuss these several matters separately and to deal first with the milling of wheat.

Milling

Normally white flour is the most valuable of the products of wheat milling; assuming its suitability for the product involved, it is judged for quality by the perfection with which it has been separated from the seed coat. This may be assessed by means of a colorimeter or by the estimation of its ash content.

The maximum yield of flour is one standard by which a miller will judge quality. But another of equal importance will be the ease with which that yield can be obtained, in terms of rate of manufacture and amount of machinery required. The roller process, which represents the most accurate and economical method of milling, involves the opening of the grain by passage through fluted rolls, followed by the cleaning of adhering endosperm from the bran in further rolling processes, and the gradual reduction of the separated endosperm by still more millings now between smooth rollers. At each stage the products of milling are classified by one or more types of sifting.



Endosperm particles from different varieties of wheat (Above) *Yeoman—hard.* (Below) *Scandia—soft*

The success of this method of separation requires that the bran shall flatten when it is rolled and that the endosperm shall powder. If, however, the bran is brittle and frays, powder will be formed which will enter the flour. Weathering of the crop is a common cause of increasing the fragility of bran, possibly because of the separation of its inner and outer layers. High-quality milling wheat has thus to be smooth-skinned and unweathered. Obviously, if the grain is thin and incompletely developed, the ratio of bran to flour must increase and its usefulness for milling must decrease. These are, however, really forms of damage that are caused by accidents of environment and can scarcely be looked upon as in any way intrinsic to the wheat.

If the discussion is limited to properly developed and undamaged grains, then other considerations are involved. Though wheats vary in size very considerably according to their breeding, large-grained wheats may weigh more than 65 g. per 1,000 and small grains less than 25 g. and though the thickness of their seed coats is remarkably consistent, 64–68μ, the endosperm content is not greatly affected by size. The results of dissection suggest that the range of endosperm content in wheat in relation to

size is no more than from 81–83% by weight of the whole grain.

Here, then, is set a theoretical limit of yield in white flour milling: its realisation, at any rate by the roller process, is unlikely to be fully achieved, though remarkably clean flours of more than 70% extraction are readily manufactured from good wheat. However, the important factor governing ease of production of flour is not the percentage content of endosperm, but rather its texture; this is bound up in its cellular structure. Three cases can be distinguished: first, a soft wheat in which the structure of the endosperm is almost entirely disrupted in milling, thus producing a fine powder of amorphous particles, which are mutually adhesive because of their irregularity of outline; secondly, a harder wheat in which the majority of particles retain the sharp outline of parts or complete endosperm cells (these make a coarser flour, but one which sifts and flows very easily); and, finally, a wheat which crushes with difficulty and whose ultimate particles, by the roller process, is often a clump of strongly adherent cells. Such wheats are difficult to reduce to flour fineness, but are of special use where the final product is a coarser powder, such as semolina.

These differences in texture appear to be of genetic origin, since they can be classified according to wheat variety and can be transmitted in breeding. They are, however, modified to a small extent by the composition of the grain, and where the abundance of starch is high the grain is softer, and where protein content is high it is harder. This is, however, only of minor consequence in comparison with the genetic distribution mentioned above.

If these classes are referred to as 'soft', 'hard' and 'very hard', it will be seen that the most promising type for flour milling will be the 'hard' wheat, which seems to break naturally to particles of flour fineness, but which produces a mobile powder and in which, by reason of its texture, the endosperm is cleanly removed from the bran. The 'very hard' class will clearly be suitable for semolina manufacture, the starting material for macaroni etc., and could not be used for flour production without the expenditure of excessive power in grinding. The 'soft' wheats have their place where the average particle size of the flour is required to be a minimum, as in biscuit or cake flours, though in this case rate of production and yield of flour have to be sacrificed in the interest of the special requirement of the product.

Bread

The characters by which bread is judged are: (1) *appearance*—the crust should be well shaped, untorn and a deep golden brown in colour; and (2) *texture*—the crumb should be light, uniform in its grain and soft, but sufficiently elastic to allow for cutting and spreading without breaking up.

These characters centre largely round the proteins of the flour from which the bread is prepared. The crust colour will depend on the availability of proteins or their amino acids to take part in the Maillard reactions that are responsible for browning. If these are inadequate, a pale and yellow crust results. The regularity of the loaf shape thus depends on the mechanical properties of the dough from which it is made, which are related to protein type and quantity. The regularity of grain in the crumb, the volume of the loaf and the strength of the crumb are governed by the same factor. Finally, to obtain this combination of softness and strength the moisture content of the crumb must be sufficiently high.

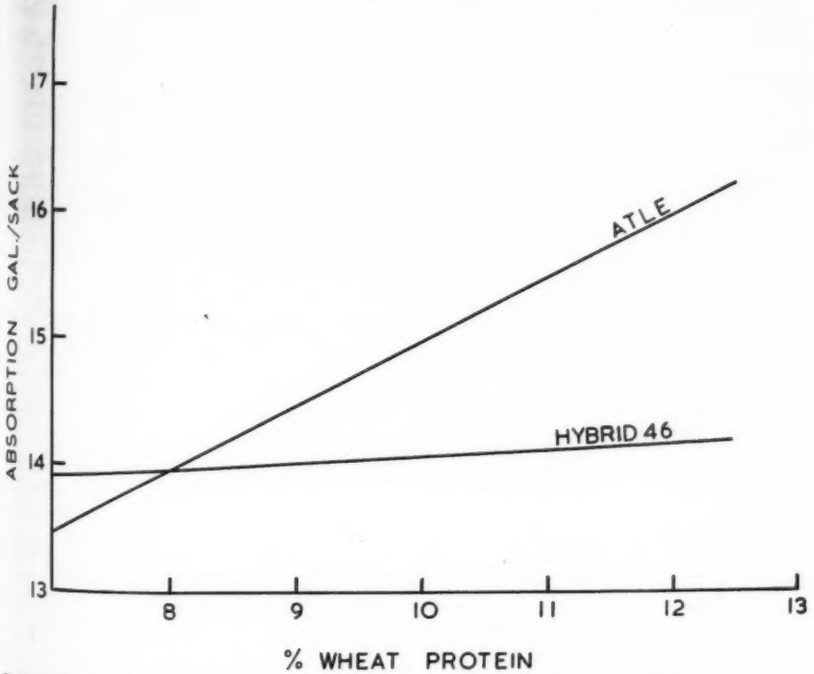
Practice varies in regard to the preparation of bread from country to country. For Great Britain it is usually accepted that a crumb moisture content of 44% and an apparent density of 0.3 are satisfactory.

To obtain this moisture content in bread crumb it is necessary to prepare a dough of approximately the same water content. Simple arithmetic will show that if flour, as sold, contains 14% of moisture some 54 lb. of water will need to be added to 100 lb. of flour to make the required dough. If such a mixture is undesirably soft and sticky, it will not be practicable to handle it satisfactorily in the bakery; its water content will have to be reduced and a drier bread baked.

Now this so-called water absorption of wheat flour can be shown to be correlated with the crude protein content either of the flour or the wheat from which it is made. If individual wheat varieties are studied, it quickly becomes apparent that the regression of water absorption upon protein content differs greatly in the coefficient to be applied to the protein (see illustration).

Similarly, the mechanical properties of dough and the value of bread are related to its crude protein content and again the coefficient of protein depends upon variety.

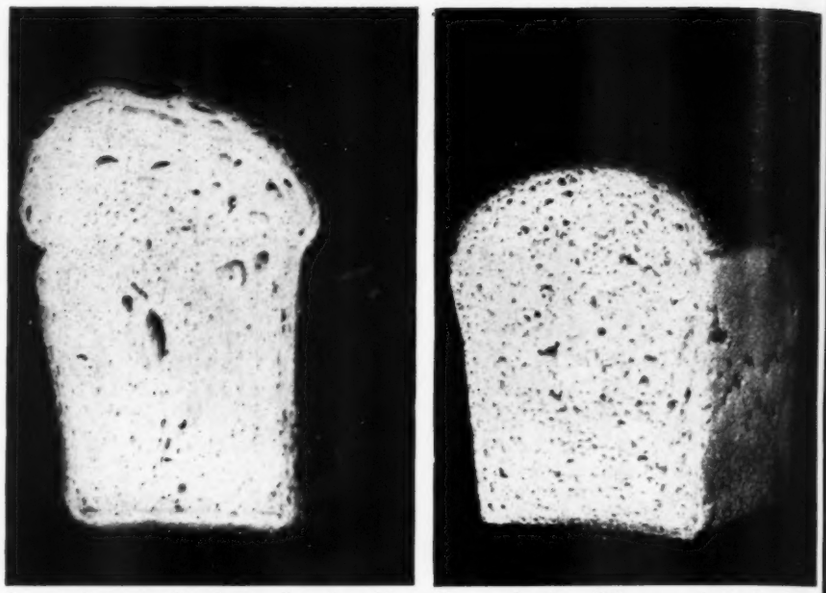
Now the conditions of water absorption, appearance, texture and loaf volume that are taken as representing satisfactory bread in British practice



Regression lines of protein content on flour water absorption, illustrating difference between the varieties Atle and Hybrid 46 in coefficient of protein content

are met when flour protein content lies between 11% and 13%, which corresponds to wheat protein of 12–14.5%.

Thus, in the simplest possible terms, one can state that for high-quality bread wheats, variety must be specified and a minimum be set upon grain protein content.



Loaves from good and poor bread-making wheats, showing differences in loaf volume and crumb texture

Biscuits and cakes

These two products are dealt with together because, though its subsequent treatment is entirely different, the flour from which they are made is milled from very similar types of wheat.

There are, of course, a great many types of biscuit, but, apart from flavour, two special characters should be mentioned: (1) the biscuit should ' bite ' and disperse easily when eaten, and (2) biscuits have to be very accurately standardised in shape and density if they are to be successfully packed, especially when a mechanical process is involved.

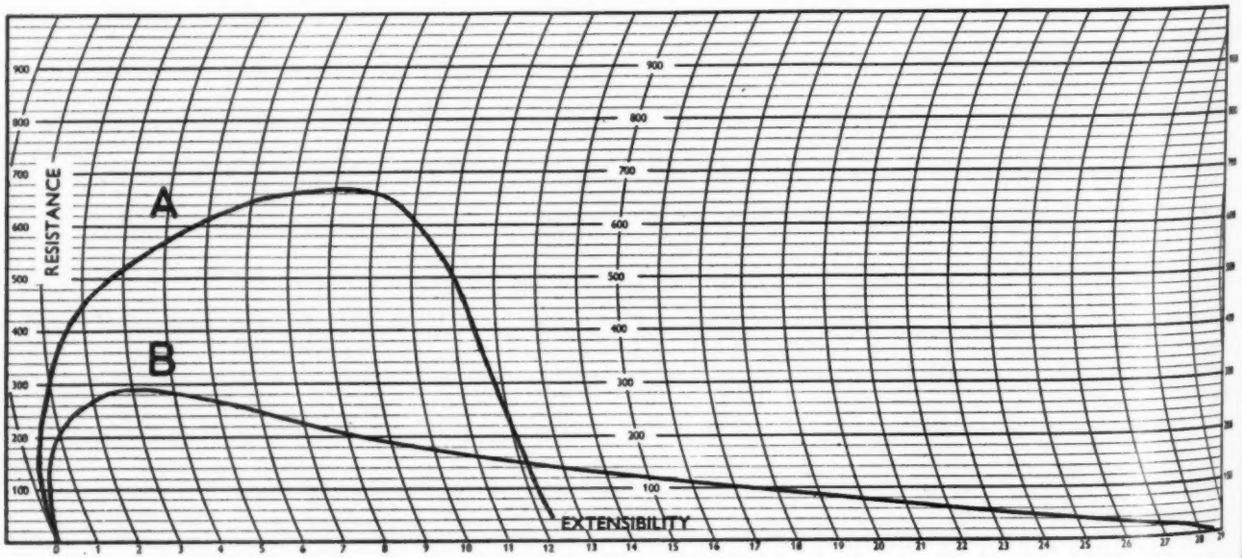
Now it is found that the hardness of biscuits increases with the quantity of water used in the mix from which they are prepared. Hence it is reasonable to assume that the water absorption of the flour should be low. The friability of the biscuit is found to be related to the fineness of the flour from which the mix is made. Hence soft wheats are the most suitable.

As to shape and density, the method of preparing biscuits involves the intimate mixing of the ingredients and then its rolling into a thin sheet from which the required shape is cut. If this shape or a predictable analogue of it is always to be made, the internal strain in the prepared dough must be a minimum, otherwise cracks and abnormalities of shape must be expected. The wheat flour should thus contain a protein whose plastic flow is adequate, but whose elastic properties are a minimum. The dough properties involved can usually be met by the proper choice of wheat variety.

Naturally, there are limits to these conditions. It would be foolish to prepare biscuits so soft and friable that they could not withstand packing. Furthermore, the plastic or viscous property of dough increases with protein content which must necessarily be above some minimum value.

Wheats of the Squarehead type have been found to possess the necessary protein character and are generally taken to be at their best when their protein content lies between 8% and 10% (wheat moisture 13.5%).

If the type of cake known as madeira is taken as representative of this class of flour food, then the product requires an extremely finely milled flour. Hence a soft wheat is needed. In some cases



Load extension curves illustrating difference in physical properties of bread and biscuit flour doughs in elasticity and extensibility (ordinates and abscissae respectively) A—bread flour B—biscuit flour

the protein of the flour is denatured before use, and hence it may be that the protein content of the wheat should be low and that no minimum need be stipulated.

One other class of flour should be mentioned which is normally used in domestic cookery for the general preparation of puddings, buns, cakes and pastry. These flours are usually mixed with aerating agents, though these are much milder in their action than the yeast fermentations used to aerate bread. This class is therefore intermediate between bread and biscuit flours and requires as its source a wheat having a moderately elastic protein of a moderate content. In Great Britain the home-grown wheats bred from Canadian Fife parents, and containing a protein content of 9–11%, have been found especially valuable for this purpose.

Alimentary pastes

Macaroni, which is perhaps the best known of a diversity of dried flour pastes, is prepared from a relatively coarse meal of wheat endosperm called semolina. A wheat is judged good for milling in this connection when it produces a maximum yield of the product free from seed coat. The appearance of the macaroni is held to be enhanced by the yellow colouring of the carotinoid pigments, which occur to a greater extent in some varieties than others and are usually avoided in the preparation of bread and biscuit flours.

In preparation, semolina is usually mixed very intimately with water and a small quantity of egg protein, and after mixture is either extruded or rolled and cut to form the required shape before it is dried. It is desired to obtain a clear and polished surface to the finished product. In cooking it is required that the shape of the tube, as in macaroni, shall remain distinct and that very little shall be dispersed in the water in which it is cooled.

These conditions are met when a high-protein wheat is used whose physical properties are elastic rather than viscous, and the specification is usually met in durum wheats from areas giving high-protein grain.

Conclusions

If the foregoing descriptions are agreed, then the criteria of quality in undamaged and pure wheat are:

(1) The grain must be properly filled.
(2) The seed coat must be smooth and bright.
(3) The endosperm texture must be correct for the purpose involved.
(4) The variety of the wheat, and hence the protein type, must be correct for the purpose.
(5) The protein content must fall within a particular range.

It may be asked whether this specification can ever be met. Most wheat users would answer that it is rare but not impossible and that a fair approximation can be made in the majority of cases. In the case of the British miller, he has at his disposal a home crop which can supply about a quarter of his total needs and from which he is able to buy a part in variety and to select varieties according to purpose. This will suffice for a great part of his soft wheat needs. Imported wheat, on the other hand, is obtainable only in mixture. However, for bread wheat flours there exists the guarantee of the Canadian authorities that the higher Graded Manitoba wheats will only be mixed from varieties equal to Marquis in their bread-making character. This wheat has, therefore, been the basis of British-milled bread flours ever since its supply made this possible.

As to the protein type of wheat varieties, their chemistry has so far not yielded any means of testing or predicting. The problem is still approached by direct milling and baking tests on hybrid wheats. The protein content of wheat is known to be largely a matter of soil and season and, while available nitrogen in soil is known often to be a limiting factor, there are good reasons for supposing that some balance of nutrients is necessary and possibly some limited range of weather conditions in which well-filled and ripened grain of a reasonably definite protein content can be produced.

Tracer Elements in Agriculture

The uses of radioisotopes are extending rapidly, and not least in the field of agriculture. At a lecture given recently to the Fertiliser Society at King's Lynn in Norfolk, England, Mr. P. Craven, B.SC., dealt with some applications of isotopes in the manufacture of fertilisers.

Dr. Libby, of the U.S.A.E.C., has estimated that radioisotopes could result in an annual saving of $200 million to American agriculture. In Britain the tracing of various sizes of particles in their passage through a fertiliser plant has been made possible by means of Na-24, while P-32 has been used for sorting basic slag for fertilisers.

Certain phosphorites are more radioactive than the average rocks of the earth's crust and it has been established that the ' activity/P_2O_5 ' ratio is fairly constant in their sulphuric acid extracts at various acid strengths, the activity increasing with ageing. Activity in the precipitated gypsum in this process is greater than that from the phosphorus and is due to daughters of U-238. It has not been found possible to differentiate between the activity, due to radioactive materials in the acid, and those precipitated with the gypsum, so that it is not possible to measure the phosphorus content of the gypsum in this way, and no process control by means of radiometry suggests itself.

There has proved to be no advantage in radiometric assay for the control of potash-ammonia fertilisers, the flame photometer being more reliable. However, when higher potash contents are met in the more concentrated fertilisers, the flame photometer becomes less trustworthy and radiometric analysis may appear more attractive.

In granulation plants small amounts of tracers have made it possible to determine the feed velocity through various sections of the granulator and drier, the granulation and drying times, the degree of mixing, the weights of materials held up in the plant, the passage times for materials in the plant, the weights of material in the plant at any time, and the relative granulation properties of the feeds and recycle materials.

Further scope for isotope applications might occur in the determination of drier flow characteristics, relative velocities of particles of various sizes, the potash content of individual granules, the homogeneity of fertiliser after bagging, the tendency of granules to form more readily from recycle material or raw feeds. Health aspects and the essential operating precautions were also discussed.

IMPROVING THE F.A.Q. WHEAT SAMPLE

W. C. JOHNSTON, R.D.A.
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Besides protein content and baking quality there is another feature that needs greater attention—a reduction in the foreign matter, largely cracked and shrivelled grain, which lowers the market value of wheat. This means more care at all stages from the preparation of the seed bed to the harvesting of the crop.

IN the immediate post-war period all grains were in short supply, but with the rehabilitation of war-ravaged areas and good seasons in the main wheat-growing countries, world production has exceeded demand. Because of this wheat selling has become more competitive. Greater emphasis has been placed on protein content and baking quality, but other factors have also become important, and included among these is the cleanliness or purity of the grain sample.

Nobody wants waste material, rubbish, cracked and damaged grain, or wheat contaminated by obnoxious smells and taints. Not only is this waste material useless, but its presence increases the cost of transport and reduces the price paid for the grain.

The grain standard

Climatic conditions affect both crop growth and harvesting operations, and because these are different each year there is a variation in the standard and quality of the grain from season to season and State to State.

To ascertain the grain standard in each State samples are drawn from every receiving centre in quantities proportionate to the amount of grain in each consignment.

These samples are bulked and mixed and the resultant grain mass represents a fair average of the wheat harvested. This representative sample then becomes the ' fair average quality ' (or f.a.q.) sample.

The Department of Chemistry analyses the sample to ascertain the protein, mineral and ash content of the wheat and its baking qualities. Before they do this they pass it through a sieve of 2-mm. standard to separate the useful grain from the foreign matter or rubbish.

Definition of foreign matter

Foreign matter includes cracked and shrivelled wheat grains, chaff, broken wheat stems, large weed seeds, such as wild oats, barley and sheep weed, small seeds like wild mustard, melilotus and charlock, dirt and other extraneous material. It is not practicable to remove this foreign matter in the field at harvest time, but with care and proper adjustment of harvesting machinery it should be possible to keep below a 3.5% total of foreign matter.

Obnoxious impurities which stain or taint the wheat and flour sample are a different matter. Star thistle seeds are difficult to grade out and these darken the flour. Melilot seeds, gum tips, smut and mould develop flavours which make the derived flour objectionable as food.

Melilotus, in particular, imparts taste and smell to grain, which once absorbed cannot be removed, even though the seeds themselves are not difficult to separate from the sample by screening before milling.

It is thought that most of the tainting from melilotus occurs during harvesting. The melilotus plants are crushed and damaged by the machinery and the obnoxious taints are readily absorbed by the grain.

The only satisfactory way to prevent grain becoming spoiled by this weed is to concentrate on cultivation and herbicide spraying to check the growth of the melilotus while it is still small. This will reduce the number of these plants present at harvest time and so lessen the contamination.

An examination of the foreign matter in the f.a.q. sample shows that 88% of it consists of cracked and shrivelled wheat grains; 8.5% is chaff, other cereal grains and large weed seeds; and 3.5% is small weed seeds and dirt.

It is obvious that the greatest individual item of foreign matter is the cracked and shrivelled grain. Anything done to reduce the amount of damaged grain would lower the percentage of foreign matter.

Table 1
Analysis of f.a.q. standard sample of wheat

Season	*Bushel weight, lb.*	*Foreign matter, %*
1934–35 ..	60½	4.2
1935–36 ..	63½	4.0
1936–37 ..	63	2.6
1937–38 ..	60½	2.6
1938–39 ..	64½	3.3
1939–40 ..	64½	2.6
1940–41 ..	63½	4.2
1941–42 ..	62½	5.0
1942–43 ..	63	3.2
1943–44 ..	64	3.2
1944–45 ..	63	3.7
Mean for 11 years ..	62.95	3.51
1945–46 ..	61½	4.3
1946–47 ..	61½	3.8
1947–48 ..	61	4.4
1948–49 ..	63½	3.5
1949–50 ..	62	3.6
1950–51 ..	64	3.6
1951–52 ..	63	5.6
1952–53 ..	63	4.7
1953–54 ..	63¾	3.7
1954–55 ..	64½	2.8
1955–56 ..	64	3.7
Mean for 11 years ..	62.89	3.97
Mean for 22 years ..	62.92	3.74

Recent deterioration

The bushel weight of South Australian wheat for the last 22 years, together with the percentage of foreign matter, is shown in Table 1. The figures are arranged in two 11-year periods.

Examination of the bushel weights shows a range from 60½ lb. to 64½ lb. and a mean weight of almost 63 lb. per bushel for the 22 years, as well as for each 11-year period. This suggests that the seasons in each 11-year period were somewhat similar and that the quality of grain in each period is comparable.

The mean percentage of foreign matter for the 22-year period is 3.74% or 0.26% below the maximum of 4% allowed by the Wheat Board for bulk-handled wheat. This would be satisfactory if all the wheat had less than 4%, but in seven of the 22 years the percentage was above this figure, and in one year it was up to 5.6%.

The f.a.q. sample is made up by mixing a large number of individual samples. Some samples will contain a low percentage of foreign matter and some will be well above the desired standard. This means that properly harvested wheat with a low percentage of foreign matter must be mixed with badly cleaned wheat to get a 'fair average quality' parcel for sale. This penalises the good farmer who harvests clean wheat.

The mean percentage of foreign matter for the first 11-year period is 3.51%, compared with 3.97% in the second 11-year period. Although unfavourable harvesting weather in some seasons might have contributed to this difference, it is clear that there has been a definite deterioration in the standard in the last 11 years.

Improving the standard

A large number of factors affect the standard of our wheat and proper attention to any or all of these will help.

Where cropping rotations are narrow, longer intervals between crops and the development of good clover pastures, by seeding down and adequate top-dressing, will improve soil fertility.

Better soil fertility will not only enable higher-yielding crops to be grown, but will tend to build up the protein content of the grain.

Grain severely over-threshed through excessive speed

A heavy content of shrivelled grain and cleanings

(Right) *A particularly dirty sample containing seeds of wild mustard and wild turnip*

Sowing of suitable varieties of good baking quality will also help.

During the preparation of a good seed bed some of the objectionable weed seeds will be germinated and the plants killed. This will reduce the chance of tainting the grain at harvest time.

Timely spraying of associated weeds will increase yields and reduce the number of weed seeds likely to get in to the grain.

Control of wild turnip, by spraying, has reduced the competition to wheat in its early growth stages and enabled denser and heavier-yielding crops to be grown in the lighter soils.

Melilotus plants can be checked in growth, and many of them eliminated altogether, by spraying with ¾ lb. of sodium or amine 2,4-D (acid equivalent) per acre.

Care must be taken to avoid crop damage by spraying when the crop is not more than 6–9 in. high.

Crops must be allowed to mature before being harvested. The sample of grain from wheat harvested before it is ripe will contain green material which will lower the standard and lead to over-heating and the development of injurious moulds.

Reducing foreign matter

Cracked grain forms a big percentage of the foreign matter in wheat. Greater care in harvesting can eliminate much of this damaged grain and so bring about a big improvement.

Most of this cracking is due to too fast a ground speed or because the threshing mechanism of the harvest machine is not correctly set for the conditions.

Speed of harvesting

The amount of mechanical power has increased enormously during the last decade and it is not just coincidence that the amount of cracked grain has also increased.

All harvesting machinery is designed to work efficiently at a certain speed. The maker usually recommends the speed or range of speeds for which each machine has been designed.

With the power available, and in the rush and anxiety to get the wheat into the bag as quickly as possible, it is easy to exceed this speed range. Excessive speed subjects the grain to a greater amount of battering and produces more cracked grain.

Correct setting of machines

Not only will ground speed do this, but adjustments to increase the beater or drum speeds beyond the maker's recommendations can and do increase grain damage. When a new harvesting machine is bought the maker sets all adjustments on it to work efficiently. Usually the local agent or machinery expert checks and, if necessary, alters these adjustments in the field after delivery.

Provided the machine is only worked at the speed, in the weather conditions and on the wheat variety for which it is set, it will do a good job.

Some varieties thresh more easily than others and when changing from one variety to another adjustment must be made if necessary.

Humidity and temperature affect the ease of threshing. As these often change within an hour or two, further adjustments become necessary if the machine is to work at its highest efficiency.

In the cooler, damper conditions during the morning and evening adjustments are necessary to meet the changing conditions compared with the midday period. Any variation away from ideal setting for the conditions at the time can, and does, lead to greater damage to the grain in direct ratio to the incorrectness of the adjustments made.

These are just as important, or more so, than lowering or raising the comb to handle lower or higher patches of crop. Once the plant has been set for the day many operators are content to carry on without stopping to make adjustments.

In recent years the threshing drum type of machine has become much more popular, because it can work under a wider variety of crop conditions and can handle a bigger amount of material. This higher threshing ability also brings with it a greater risk of cracked grain, unless greater care is taken and more frequent adjustments are made.

It seems that, although harvesting may be somewhat slower, particularly in heavy crops, with a beater type of machine, the average operator does less damage to the grain with it.

Screening equipment

Screening riddles, sieves and draught all need proper adjustment for the weather conditions and the variety being reaped. Wind direction and amount of grain and straw taken into the machine must also be allowed for.

Shrivelled grains, chaff and small weed seeds are all taken into the harvesting machine and must there be separated from the good wheat.

Many machines are now being put on the market without screening riddles. The makers claim that they can be set to do efficient work. This may be so, but it is obvious that any variation, however slight, from the ideal setting or ideal conditions must lead to an increase in the amount of cracked grain and rubbish which reaches the siding.

The machinery manufacturers suggest that a screening riddle can be fitted to the machine should the farmer demand it. It is certainly in his interest to do so.

Harvesting conditions

Continuing to harvest when conditions have become unsuitable can be another cause of a poor sample.

Modern harvesting machinery can handle a wide range of conditions, but there is a limit to its adaptability. With the desire to get harvest over quickly it is easy to start before or to go on after conditions are suitable. Because the machine will tear off the grain and deliver it to the grain box in a slightly damaged condition, with a not too obvious increase in the percentage of rubbish, some people are inclined to reap when they should be doing something else. Even while it is raining some harvesters keep going. Although the grain may come off and clean fairly well, it will be liable to heat and deteriorate.

Summary of recommendations

To improve the standard, attention must be given to fertility-improving rotations, good seed bed preparation, selection of suitable varieties and weed control by cultivation and spraying.

Before harvesting commences the crop must be mature and the machinery put into good working condition.

Efficient use of harvest machines must be the watchword of every operator. Included with this is proper drum setting, correct rate of ground speed and careful attention to the adjustments necessary to cope with changing crop and climatic conditions during harvest.

THE CONSERVATION OF GRAIN IN BRITAIN

C. G. HANDLEY

(*Aldersley Engineers, Ltd.*)

This is a review of contemporary practice in the handling and storage of grain, and of progress towards the full preservation of its quality under British conditions, by the provision of proper drying and storage facilities.

IN Great Britain the change over from long - standing traditional methods to a mechanised technique of harvesting and storage of grain crops is now well advanced.

As ever-increasing amounts of grain became available at the time of cutting, the fundamental changes in procedure and management were necessarily something of an evolutionary process, a process that is not eased by urgency. Consequently the main developments have been not so much the invention of new principles, but rather the taking of necessary steps to meet a better understanding of the physical peculiarities of grain.

In times of rapid change it is perhaps inevitable that the speed of re-equipment with a diversity of mechanical implements will outstrip the rate at which skill in operation can be acquired. Failure to achieve ' malting quality ' or ' milling value ' has frequently been due to lack of care in threshing, when extra attention to machine speeds and settings would eliminate much of the skinned, split and broken grain which can initiate rapid mould growth and cause premature deterioration.

Correct harvesting essential

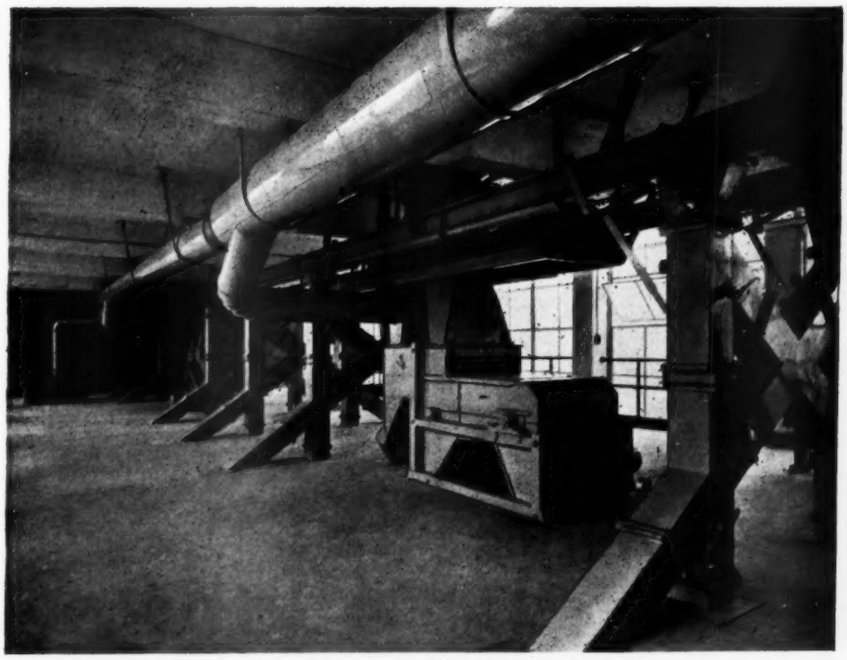
The first essential to satisfactory storage is, therefore, careful harvesting at the right time to ensure that the grain is ripe and is as clean and undamaged as possible. No subsequent system of drying or storage can compensate for previous damage, and the most that can be expected is that the keeping quality of damaged grain will not be further impaired.

The majority of British farmers are, of course, highly skilled in judgment of weather and crop and, as expected, have produced grain of a gradually improved standard of quality. However, the optimum must be the best possible condition which the season will allow and, despite all precautions, the farmer may be forced to cut the crop in unfavourable conditions.

Pre-cleaning

The incidence of immature, sprouted and damaged grains is generally greater during a wet season and under adverse conditions, such as in a badly laid crop with a vigorous weed population, a considerable proportion of contaminant will also be collected with the grain. Bulked grain, if heavily contaminated with weed stem, broken leaf and like green matter, will deteriorate rapidly, since such impurities are damper than the grain and ' heat ' more readily. A preliminary separating operation must, therefore, be carried out as soon as possible. Chopped straw and chaff, weed heads and small seeds will affect or obstruct the flow of both grain and air in most types of drying equipment, thus contributing to uneven drying and difficulties in moisture control. Adequate pre-cleaning has proved to be an essential preliminary to successful drying and storage.

The machinery should be capable of dealing with grain and impurities at a rate calculated to cover the peak deliveries likely to be made to the plant. Several types of pre-cleaner are available, but the minimum separation recommended is that obtained by two oscillating sieves. The upper sieve tails over the large impurities, the grain passing through to the lower sieve, which sifts out small seeds, sand and fine impurities. Magnetic separators and aspirators are added refinements, but husk, awns and ingrained dirt which is not responsive to the



Pre-cleaners on over-bin floor, showing aspiration trunking, chain conveyors and spouting to 18 bins

sieve action will be released during the subsequent drying process and may, with advantage, be extracted later.

Buffer storage

In planning the receiving end of new storage installations the more extensive use of bulk transport has not been overlooked. A dumping hopper, of no less capacity than the largest vehicle, is provided so that grain may be discharged rapidly and the vehicle released in a few minutes. Automatic weighers are installed ahead of the pre-cleaning machines.

The increasing use of bulk transport has also necessitated the provision of ' buffer storage '. Such storage caters for unpredictable rates of grain delivery and allows the drying and handling plant to operate smoothly within its capacity, since any accumulated reserve can be worked on during slack periods or at night.

Storage bins of steel construction are frequently used with advantage and in preference to other types for reserve or buffer storage. They are fireproof and vermin-proof and can be constructed to suit any normal requirements regarding size. The bins should be self-emptying; they are usually supported on a steel framework having the hoppers suspended within at the required height.

The number and size of bins will depend upon the variety and size of consignments to be stored and their construction must be related to the ' holding period ' required for the grain. They should preferably be available for use after the pre-cleaning operation and equipped for applying forced ventilation to the undried grain. Flat-bottomed bins ventilated through a porous floor are unsuitable, since the level of stock fluctuates according to deliveries and static grain in the corners may spoil before it can be conveniently moved. Hoppered bins, fitted with a pyramid or cruciform for distribution of ventilating air, have proved satisfactory and can be used eventually for the storage of dry grain or as out-loading bins discharging directly into bulk transport.

Self-emptying steel storage bins with suspended hoppers

Under average British climatic conditions the use of unheated air for the ventilation of damp grain is not intended for drying, but to dissipate heat and delay deterioration. Spontaneous heat production in a mass of damp grain may be prevented if its temperature is reduced and maintained below about 5°C, but even at low temperature its germinating power will fade, mould growth gradually spreads and fat acidity develops.

Cooling by forced ventilation is, therefore, only a temporary measure. By delaying deterioration it can help to spread the load over a longer period, but must always be followed by proper drying as soon as possible.

Drying

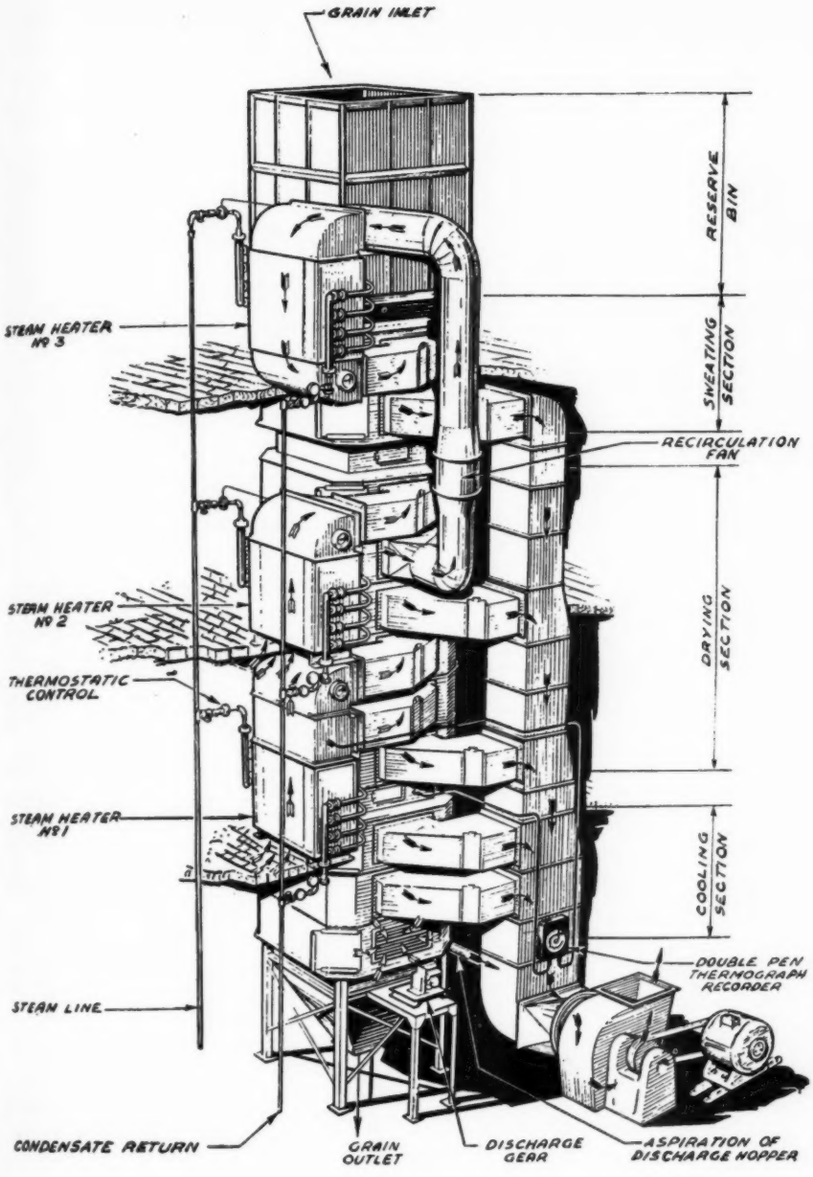
Grain is a living and breathing organism and its activity is, in principle, controlled by available oxygen, heat and water—the elements essential to life. Methods of limiting the availability of oxygen and heat have been tried, including storage in hermetically-sealed containers and cooling by refrigeration, but such methods are either expensive or have practical disadvantages. Removal of water by thermal evaporation is, at present, the most practical and, so far, the most economical method employed.

For the continuous evaporation of moisture from grain, numerous types of equipment are available; these are all based on subjecting a layer of grain to currents of heated air for a time which varies with different designs. Many of them, mainly in the hands of farmers, operate on a time factor as low as 30 minutes, with consequent over - heating, case - hardening and under-cooling. *Proper drying cannot be achieved unless adequate time is allowed*—in fact, the most successful driers currently employ a time factor of no less than two hours for the whole drying and cooling process.

The evils associated with too rapid drying, and the resultant prejudice against farm-dried grain, led to a decided swing in favour of very slow batch-drying methods (*e.g.* bulk bin driers and platform driers for bagged grain), whereby any miscalculation would be unlikely to cause serious damage.

Progress with continuous driers naturally lay between these extremes,

Under-bin space showing steel hoppers, discharge control gates, screw conveyor and provision for forced ventilation of hopper storage



A steam-heated, multi-stage continuous air drier

but with conveyor driers, and also with driers in which grain passes vertically downwards between parallel walls of perforated metal, serious over-heating could only be overcome by introducing mixing devices, by reversing the flow of air at frequent intervals, or by limiting the inlet temperature. These difficulties led to the adoption of a system, now widely used, where the grain travels downwards over a series of inverted troughs, horizontal rows being alternately connected to inlet and exhaust. With this form of construction better mixing is obtained and no grain is in contact with a hot zone for sufficient time to cause damage.

This development has, in one leading make of drier, been taken a stage further by the use of small units, each complete with one set of inlet and exhaust troughs. When assembled, each unit is placed at 90° to the one below; the grain is deflected in four directions instead of two and air is passed in a different direction through each succecssive section. In addition, this patent drier incorporates a technique which is the outcome of much research and experience in drying for the brewing and milling industries. The drying column is surmounted by a 'sweating' section, in which hot humid air is passed through the wet grain. The high humidity keeps the outer skins moist until heat has penetrated to the centre of each grain, whilst, at the same time, differences in moisture content are levelled out. Treatment in this section ensures that the grain enters the drying section properly heated right through and at uniform moisture content. Thereafter all grains receive the same treatment and final moisture content differences do not occur.

In the drying section moisture is given off rapidly from the inside of the grain, due to its internal temperature, and is removed from its surface by the hot dry air. A final stage, using cold air, ensures that the grain is thoroughly cooled before it leaves the machine. The discharge mechanism consists of a reciprocating grid, capable of infinitely variable adjustment, and fitted at the base of the column. Adjustment of this mechanism controls the output rate of grain and hence the moisture extracted.

These multi-stage features permit the use of much higher hot air temperatures than those normally imposed on other types of drier. Various forms of direct or indirect heating are used for this purpose, each being capable of accurate adjustment and fitted with thermostatic or fully automatic controls.

Throughout this development the aim has been to attain complete control of the whole process and, on these plants, instruments recording both air and grain temperature reveal the accuracy of control achieved.

Storage

The requisite degree of dryness to be obtained depends mainly on the period for which the grain is to be stored. For short periods, say up to one month in bulk, its moisture content should not exceed 16%; for seasonal storage (*i.e.* up to 12 months), not more than 14%; and for long-term storage (*e.g.* carry-over from more than one season), below 12% and down even to 10%.

Storage period also determines the type of installation necessary. For short periods, flat storage on open floors or in shallow bins is suitable, even for quite large quantities, except for the cost of moving the grain.

For seasonal and long-term storage, it is now generally accepted that the most economical method of storing grain is in bulk or in bins of considerable depth. The need for segregation of different varieties or qualities, the overall capacity needed and the limits imposed by mechanical strength and foundation stability are all factors governing the optimal size and number of units.

In the past, bins of laminated timber construction were favoured by maltsters and millers. It is now appreciated, however, that as such bins are far from airtight, they are susceptible to changes in atmospheric humidity, need special protection from the weather, are prone to insect infestation and involve fire risk.

Under the protection of a suitable roof, or inside an existing building, steel bins provide excellent accommodation for dry grain. They may be circular or square units, installed separately or nested together, and can be quickly erected. Steel bins are lighter and cheaper than concrete and, with regular painting, may be regarded as clean and durable.

Reinforced concrete is adaptable to any arrangement of bins, of any shape and size, and forms a permanent monolithic* structure requiring the minimum of maintenance. With bins of large capacity, having low surface to volume ratio, silos of this type can be extremely economical in construction and in cost of auxiliary mechanical equipment.

If grain is properly dried to a ' safe moisture content ', ventilation during storage is both unnecessary and undesirable. Resulting from ventilation, moisture gain may cause the grain to deteriorate or, alternatively, further moisture extraction represents loss of weight to be paid for. Periodic recirculation of stored grain should be the only operation necessary to preserve its wholesome condition.

Handling equipment

In an installation which is primarily for seasonal or long-term storage the facilities provided for movement of grain can be of comparatively low capacity, whereas in a merchant or transit silo the handling plant should be designed for peak loads and with ability to carry out several operations simultaneously.

*Monolith: a single block of stone.

For lifting grain vertically bucket elevators are cheaper to run than chain-link elevators. Chain-link conveyors are commonly used for horizontal movement, running costs being lower than for belt or screw conveyors. Though more costly, pneumatic handling has a special appeal, as it will move grain in any direction and a single unit can perform a multiplicity of operations.

Recent developments in design of mobile pneumatic conveyors have overcome the major difficulties of handling grain from bulk vehicles, rail wagons and water transport. These self-contained powered units, equipped with easily assembled lengths of pipeline, can rapidly transfer grain to or from transport which cannot be conveniently manoeuvred to fixed intake or out-loading points, and their extending use should release much of the valuable working space now occupied by travelling gantries and other mechanical systems at dockside installations.

Summary

The handling operations involved should be the main factor determining the layout of new storage accommodation and the requisite equipment should be planned before any structural work is begun. There will then be no difficulty in accommodating the machinery to provide maximum flexibility in operation with minimum wastage of space. *The smooth and efficient handling of bulk grain and the full conservation of its quality during storage can only be achieved with correctly designed equipment, planned in every detail before construction commences.*

Grain and Grass Drying

Some of the ways in which electricity helps the farmer, and in particular helps him to beat the weather, were featured in the electricity exhibit organised jointly by the Electrical Development Association and the South of Scotland Electricity Board at the Scottish Dairy Show this year.

Last year harvesting conditions were exceptionally bad and crops suffered extensive damage through lack of suitable drying equipment.

Equipment shown on the stand included a multi-purpose crop drier suitable for a 20-hole platform, a cold-blow barn hay drier, a 20-hole platform grain drier and a silo ventilating unit suitable for six 10-ft. diameter silos of 910 sacks capacity. Meters for measuring the moisture content of grain showed the simplicity and precision of the electrical method.

There was also a working exhibit of electrical equipment for grain handling and conveying, including a conveyor-elevator and an auger type conveyor, as well as a scale model of a grain-drying installation.

The cost factors have now been determined: grain drying is approximately 11*s.* per ton, hay drying with cold air 22*s.* per ton and with warmed air from £2–£3 per ton, depending on the moisture content of the hay.

Average Cereal Consumption in the U.K. in 1954*

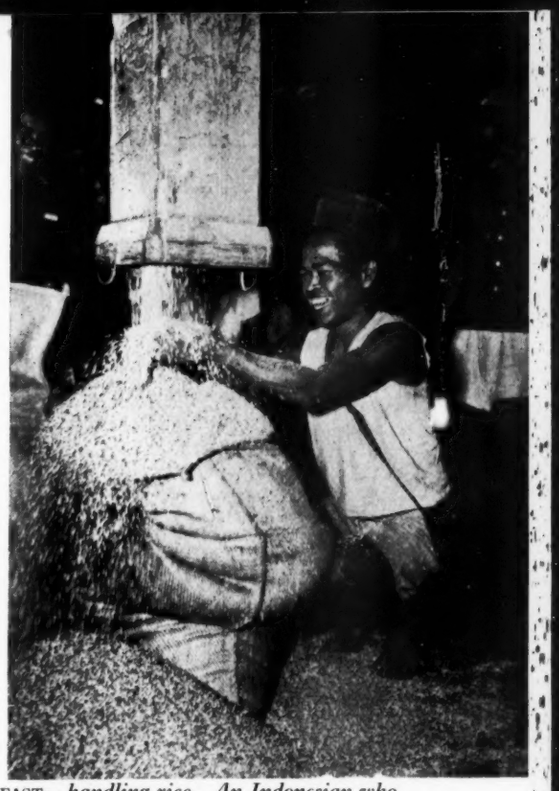
	oz. per head per week	%
National bread, brown	2.00	69.7
National bread, other	49.18	
White bread	0.63	
Wholewheat and wholemeal bread	2.04	
Malt bread	0.18	
Other bread	2.25	
Self-raising flour	6.93	10.9
Other flour	1.88	
Buns, scones and teacakes	1.60	6.6
Cakes and pastries	3.69	
Biscuits	4.99	6.2
Breakfast cereals and puddings	1.94	2.4
Other cereals and products	3.41	4.2

*Ministry of Agriculture, Fisheries and Food, 1954, ' Domestic Food Consumption and Expenditure '.

HAZARDS OF GRAIN DUST

Reducing dangers to health of workers handling grain

The International Labour Organisation in Geneva has recently made a study of the dangers to health of undue exposure to grain dust and has put forward certain recommendations. At the beginning of the long journey from the producing country to its final destination the total weight of grain may contain anything from 2% to as much as 14% of dust and, although much of this dust is removed during various stages of handling along the route, the practice of returning the dust and dirt to the bulk grain to make up weight is at present far too widespread.



EAST—*handling rice. An Indonesian who has been filling sacks*

EXCESSIVE exposure to grain dust may be the cause of many ailments among workers who handle grain cargoes, ranging from irritation of the eyes, nose and throat to bronchitis, skin diseases and lung conditions resembling pneumoconiosis. The dust and dirt in the grain which gives rise to these conditions includes mineral substances, bits of the husk, the fine hairs that break off the husk, protein fractions from the grain—which sometimes cause allergic sensitisation—the spores of moulds and fungi, and even tiny insects. Although much of the dust is removed during transit, it is often systematically restored to the cargoes to make up the weight lost and in this way is passed along to the next group of handlers.

Loading and unloading methods

The handling of grain cargoes at ports may involve the loading of ships from, or the unloading of ships into, motor trucks, railway wagons, barges, warehouses or silos. Transfer from ship to shore or from ship to barge and vice versa may be carried out by various methods or combinations of methods. Four methods are most commonly employed: gravity, manual, mechanical and pneumatic.

Most of the larger grain ports in the countries covered in the study are equipped with pneumatic (suction) installations and when these are well designed and properly operated the quantity of dust is small. Many of the smaller ports still employ mechanical and manual methods of handling grain that give rise to considerable quantities of dust.

Whatever the method employed, there is liable to be much dust in cleaning-up operations and sometimes in maintenance work, unless proper precautions are taken. The handling of bagged grain does not appear to give rise to any serious dust problems.

WEST—*wheat pours into the hold of a barge in Rotterdam harbour watched by the bargeman*

Sources of exposure

Nine principal sources of dust in the handling process have been given by German investigators. In descending order of importance these are:

1. The scales on which the grain is weighed and put into bags.
2. Trimming grain by shovel in storage compartments.
3. The scales at which the grain is weighed on intake and discharge from the vessel.
4. Loading and unloading railway wagons.

5. Unloading barges with grabs or bucket hoists.

6. Blowing grain into store-rooms.

7. Transport on worm or belt conveyors.

8. Testing grain for quality and for the presence of vermin.

9. Shaking and sorting bags.

While the problem of exposure to grain dust was being studied many examples came to light of the conditions of particular workers in particular instances. In one firm the air in the grain storage compartments becomes so laden with dust that they cannot be entered after they have been filled with grain until two days have elapsed. Another instance was in the inspection and cleaning of silo bins. Here the workers are roped and let down into the bins by a winch or by hand and brooms used for cleaning. If the grain is damp, much adheres to the silo walls. When the workers enter the bins they are exposed to the risk of burial or suffocation by carbon dioxide, besides being exposed to the dust. The use of brooms and shovels in cleaning operations always raises a lot of dust and is a frequent source of trouble.

Recommendations

The three main recommendations of the ILO to overcome the risks of exposure to grain dust are:

1. Cleaning the grain before it reaches the port of loading.

2. Loading and unloading by dust-tight pneumatic equipment.

3. Provision of respirators for operations that cannot be made dustproof, *e.g.* cleaning holds and cleaning dust-extraction chambers.

The report also states that in cleaning-up operations the dust produced can be substantially reduced by the use of vacuum equipment. It is essential that this should be flame-proof because of the explosion risk. Vacuum cleaners should not be used as blowers for removing dust from motors and scales, and hand-bellows should not be used for cleaning scales. Technical measures should be supplemented by medical checks on workers and exposure to risk could be reduced by shortening the spells of work in dust-laden atmospheres or by arranging for some rotation of work among different types of cargo. *The greatest single contribution to the elimination of hazards to health from handling grain would be the abandonment of the practice of returning dust and dirt to grain in transit in order to make up weight.*

'Grain Drying and Storage on the Farm'

Film produced by Maxwell Munden with C. Culpin as technical adviser. A C.O.I. production, filmed by Film Workshop Ltd. for the British Ministry of Agriculture—running time: 23 min., black and white, sound. Available from the Central Film Library, London, W.3.

The film opens with scenes of binding, stooking and stacking, illustrating the traditional method of harvesting, with natural drying and safe storage in the stack. Shots of combines in operation follow, accompanying a mention of the increase in numbers of these machines in recent years and the problems which have resulted, particularly where bulk storage is intended. A visit to the National Institute of Agricultural Engineering with shots of laboratory work in progress provides a background to the research aspect and is followed by practical recommendations of safe moisture levels and conditions for farm-stored grain.

The basic principle of the drying process is then illustrated by an animated diagram which shows how warmed air, when passed through a ventilated silo, extracts moisture from the grain. Comments on the wide range of drying equipment available are followed by visits to several farms to see examples of the main types of installation.

Platform driers.—The first visit is to a platform drier. Alternative methods of heating are seen. Loading and unloading are demonstrated and good layout features are noted. Reference is made to moisture testing and temperature control; two moisture testers particularly suited for testing grain in sacks are demonstrated.

Tray driers.—A mobile tray drier, another type of batch drier, is seen at the next farm visited and the film shows its salient features. Dry grain is shown both being sacked off and being removed in bulk from the drier. There follows an animated diagram of a tray drier with a fixed inclined floor, which may also be used for grass or hay drying.

Ventilated silo driers.—The film then shows a tractor and trailer drawing up to a ventilated silo drier in which the metal silo walls are exposed and support the roof. The shots follow the grain from the trailer into the wet pit and finally into a ventilated silo. A close-up of the perforated metal floor is shown. The waste-heat unit is demonstrated and also the methods by which the desired amount of heat is selected. An animated diagram of the drying process follows at this stage. The technique of sampling bulk grain for tests of moisture content is shown, followed by a demonstration of two moisture testers which require the grain to be milled. An animated diagram then illustrates the drying technique to be adopted when very wet grain is received.

Radially ventilated silos.—The operating principle of radially ventilated silos is next dealt with and a farm installation combining radial drying silos and square storage silos is visited. The main features of the plant are shown, including an old threshing machine serving as a grain cleaner. At this point a new type of grain cleaner is shown and briefly described.

Continuous driers.—The film moves on to discuss continuous driers, which, it is suggested, may be preferred by farmers who wish to dry the grain soon after it comes in from the combine prior to bulk storage or sale off the farm. The first drier of this type shown deals with over 300 tons in a season and it is of the cascade type. Grain is followed on its passage from the pit to the drier, which is seen being filled up ready for operation. The drier is described and dried grain is shown being conveyed by shaker conveyors and bucket elevator into storage bins.

Continuous tower driers.—At the next farm another type of continuous drier is described. The machine is a small oil-fired vertical tower type. The passage of air from the fan and heater unit is traced and a close-up of grain moving down the tower is shown.

The film ends with the advice that the farmer's final decision depends on *his* farm and *its* particular needs. Planning and expert advice are essential to obtain the full advantage of grain drying.

CONTROL OF RATS AND MICE IN GRAIN STORAGE

E. W. BENTLEY, B.SC., PH.D.
(*Ministry of Agriculture, Fisheries and Food, Infestation Control Division*)

Estimates of the damage done to stored grain by rats and mice are often little better than guesses. No one disputes, however, that on a world scale enormous losses occur. These losses largely depend on the suitability of the storage facilities and the standard of warehouse maintenance; but even under good conditions rats and mice may occasionally become a menace.

IN some grain stores adequate attention to proofing is all that will be necessary to eliminate the rats that are present. This is because rats (but not mice) are unable to survive for more than a few days without water or, at any rate, without food of very high water content. Thus, if they are trapped in a building, with no dripping taps or other water sources, they will soon die. So, too, if they are shut in silo bins, but for reasons of hygiene it is always sound practice to see that the safety grilles, normally used when bins are opened for airing, are rat-proof.

Apart from proofing, the only control measures that are fully effective against rats and mice are poisoning and fumigation. The latter will not be discussed further except to say that dosages of methyl bromide and other gases that are used against grain insects are usually more than adequate to kill small rodents.

Rat poisons

Using poisons against rats and mice in grain stores presents one or two special problems, but otherwise differs little from control in other indoor environments. The acute poisons, such as alpha naphthylthiourea, zinc phosphide and arsenious oxide, have been largely supplanted by the anticoagulants, of which warfarin [3-(α-acetonyl benzyl-2-acetylethyl)-4 hydroxycoumarin], fumarin [3-(1[α furan] 2-acetylethyl)-4 hydroxycoumarin], coumachlor [3-(1 parachlorobenzene 2-acetylethyl) 4 hydroxycoumarin] and pival [2-pivalyl 1:3 indanedione] are probably the best known at present. These poisons are incorporated in cereal and other baits at concentrations of the order of 0.025% by weight and must be eaten freely by the brown rat, *Rattus norvegicus*, for usually a minimum of three days before they become effective. The ship rat, *R. rattus*, and the house mouse take longer to kill. Alternatively, the sodium and other salts of these anticoagulants may be dissolved in water and used as liquid baits.

A third method, now becoming more popular, is to mix one of the anticoagulants with an inert diluent, such as talc, and spread it in holes and along runways, where the rodents will pick it up on their feet and fur. If the dust is skilfully placed, a concentration of about 1% usually ensures that, in the course of the animals' normal cleaning behaviour, a lethal dose will be ingested within a few days.

Before deciding what particular control method or combination of methods to use, the species doing the damage must be identified and its approximate numbers and the places where it is running and living must be discovered. There is insufficient space in a short article to elaborate on this, but reference may be made to handbooks of rat control, such as Barnett[1], Steiniger[2] and Lhoste[3].

If the species concerned is *R. rattus*, it will probably be best to use warfarin or fumarin at 0.025% in a cereal bait. A rodenticidal dust may be used in conjunction with the bait but is unlikely to be effective alone. This may be because *R. rattus* has a lesser tendency than *R. norvegicus* to keep to the same runways each day, and be-

Crown Copyright

Mouse damage to a stack of barley

cause it makes more use of vertical surfaces, which are difficult to coat with dust. It also carries its body higher and so tends to pick up less dust on its fur (Henschel[4]). Liquid baits are similarly often unsuccessful against *R. rattus* except in very dry weather, for it may be able to obtain drinking water in eaves and valley gutters not normally explored by the common rat.

R. norvegicus, too, can best be controlled by laying poisoned cereal baits; alternatively, a dust may be used—or any combination of solid bait, dust and liquid bait.

One difficulty that arises in grain stores in using solid baits against either rat species is that the cereal that is chosen may be less attractive than that on which the rodents are living. There are no hard and fast rules about the order of preference of rats for various cereals. However, it is generally true that wheat is very acceptable. If, therefore, other cereals fail to give results, wheat should next be tried.

Poison bait formulations

A typical bait formulation recommended for rats may consist of 85% pinhead oatmeal, 5% mineral oil (to cause the poison to adhere), 5% sugar (to offset the slight unpalatability of the mineral oil) and 5% of the poison, diluted in a corn-starch or fine oatmeal base. If the rats are living on wheat, this type of bait may be ignored even when kibbled wheat is substituted for pinhead oatmeal. Success may often still be had, however, by using wheat that has been soaked overnight in water instead of the oily bait, for it is well known that rats usually prefer damp baits to dry. Even so it may be several days before the rats begin to visit the baiting points. Much depends on how skilfully these are sited.

A disadvantage of damp baits is that they quickly dry out. This means that frequent visits will be required to renew them. Alternatively, 5% glycerine may be added. This is particularly effective in dry climates and, in any case, usually makes the baits more palatable to rats.

Control of mice

The control of the house mouse, *Mus musculus*, can be extremely difficult. It is able to live for long periods without drinking, provided that its food is not too dry. If food and shelter is plentiful, its daily range of movement may be small and, when it feeds, it tends to nibble at a large number of points rather than to feed regularly, as the common rat tends to do, at a small number of points. Thus it is not surprising that both poison baits and dusts, as used at present, are sometimes ineffective, especially against medium-sized infestations. Until more research has been done it is therefore only possible to recommend that, short of fumigation, these methods should be tried in combination. Where the grain is bagged success may then depend on the size of the stacks. The narrower these are, the easier it should be to achieve control.

REFERENCES

1. Barnett, S. A.: 'Infestation Control. Rats and Mice', 1946. (London: H.M.S.O.)
2. Steiniger, F.: 'Rattenbiologie und Rattenbekämpfung', 1952. (Stuttgart: Ferdinand Enke.)
3. Lhoste, J.: 'Les Rongeurs Domestiques Nuisibles', 1955. (Paris: Dunod.)
4. Henschel, J.: *Anz. Schädlingsk.*, 1955, **28**, 97–101.

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Factors of Quality in Wheat

A SYMPOSIUM on wheat was arranged recently at the new headquarters of the Society of Chemical Industry in London by the Food Group of the Society.

The meeting was held under the Chairmanship of Dr. A. J. Amos, who emphasised the importance which a knowledge of the nature and properties of gluten plays in the merchandising of wheat and in the processing of wheat products. The meeting discussed the problems as seen by the cerealist, emphasised the gaps in our knowledge and discussed lines of future research. The following is a brief summary of selected papers.

Some Aspects of the subject of interest to the Milling and Baking Industries *by M. A. Cookson* (*Joseph Rank Ltd.*).

The quantity and quality of protein in different wheat varieties, and hence flours milled from them, affects and may be reflected in the quality of bread, cakes and biscuits. Both chemical and physical methods are applied to the assessment of wheats, flours and the doughs, batters and pastes produced in the course of manufacture of baked products, but the tests are largely empirical. This paper considers various aspects of the subject from both milling and baking points of view.

Physical Properties of Wheat Protein Systems *by P. Halton* (*Research Association of British Flour Millers*).

Examination of the swelling behaviour of gluten, its viscosity when dispersed in various solvents and the rheological properties of flour-water doughs have been used in studying the properties of wheat protein. Modification of these properties by certain flour constituents, by additions such as oxidising agents and by the mechanical processing of flour into bread and other products is considered.

Chemical Aspects of Wheat Proteins *by J. Pace* (*Research Association of British Flour Millers*).

The distribution of protein in the different parts of the wheat grain is briefly described, and the status of protein fractions, derived therefrom, reviewed. Some of the characteristic features of the main endosperm proteins, which form the essential basis of the gluten complex, are described and various factors which influence the properties of gluten are discussed.

Mechano-Chemical Methods of Studying the Structure and Reactivity of Animal Fibres *by Dr. J. B. Speakman* (*Professor of Textile Industries, University of Leeds*).

Owing to their unusual elastic properties, animal fibres provide special opportunities of studying the influence of amino acid environment on side-chain reactivity and cross-linkage formation in proteins. The methods used and some of the results obtained are described.

The Study of Tissue Proteins with particular reference to the Proteins of Muscle *by Dr. S. V. Perry* (*Department of Biochemistry, University of Cambridge*).

The main components of the contractile system of muscle, actin and myosin, are soluble fibrous proteins which interact in a unique manner to give a complex of high viscosity and unusual properties. Some of the methods used and the results obtained in the biochemical study of the muscle proteins, which may be of significance for the study of the wheat proteins, are discussed.

For consumption of wheat in the U.K. see table on page 284.

TRACE ELEMENTS IN PLANT NUTRITION

' Hills peep o'er Hills, and Alps on Alps arise '—Pope

PROF. T. WALLACE, C.B.E., F.R.S.

Prof. T. Wallace, C.B.E., F.R.S., Director, Long Ashton Research Station, University of Bristol

We are privileged to be able to publish a lengthy abstract of the Fernhurst lecture which was recently given by Prof. Wallace at the Royal Society of Arts in London to a large and distinguished audience of scientists. It is a review of the progress made in this important field of research since the middle of the last century. In Part I, he gives a detailed account of the symptoms of excess and deficiency in plants. Part II will be published in the August issue.

IN analyses made of the ash of plants approximately 60 elements have been identified. Some of these have occurred so consistently as to suggest their essential nature for plant growth and others in a manner denoting that their presence is likely to be fortuitous. Studies of these elements have led to their classification, in relation to plant growth, into three groups:

(*a*) *essential* elements, regarded as necessary for the growth and reproductive processes of the plants;

(*b*) *beneficial* elements, which may produce beneficial effects on growth, but in the absence of which plants can carry out their growth and reproductive functions satisfactorily;

(*c*) ' *other* ' elements, which have not been shown to perform any useful function in growth or reproduction and whose presence in the plant may, in fact, be harmful.

So far 16 elements have been established as essential, namely: carbon, hydrogen and oxygen, and the so-called mineral nutrients, nitrogen, phosphorus, calcium, magnesium, potassium, sulphur, iron, manganese, boron, copper, zinc, molybdenum and chlorine. Examples of the beneficial elements are sodium, silicon, aluminium and bromine.

The 13 essential mineral nutrients are divided into two sub-groups:

(i) *Major* or *macro-nutrients*—nitrogen, phosphorus, calcium, magnesium, potassium and sulphur;

(ii) *Minor* or *trace elements* or *micro-nutrients* — iron, manganese, boron, copper, zinc, molybdenum and chlorine.

Chlorine has been placed tentatively in the trace elements group, though its position would seem to be intermediate between the major and minor groups.

The division of essential elements into major and trace elements groups is not based on the relative importance of the elements in the nutrition of plants, but merely reflects the quantities of the elements usually present in plants—major elements occur in plants in relatively large amounts and trace elements in relatively small amounts. Thus, whereas we generally record the contents of major elements in plants on a percentage basis, trace elements are usually expressed as parts per million.

On this purely quantitative basis, *non-essential* trace elements may also occur in groups (*b*) beneficial, and (*c*) ' other ' elements, and indeed a number of these trace elements, known for their harmful effects on crops and livestock, are, in the present stage of knowledge, grouped in (*c*). The present position of the elements in groups (*b*) and (*c*) should not be regarded as final, since further investigations, using more refined methods than are at present available, may alter their grouping. This relates especially to trace elements; thus, molybdenum and chlorine have been shown only recently to be essential and placed in group (*a*).

Elements in all three groups may affect the growth of plants, the 'other' elements, so far as is known, only adversely. The overall picture of the mineral content of plants in relation to their nutrition is referred to as the *mineral status*.

Other points that are of interest in considering problems of trace elements in plants are as follows:

1. Although plants show considerable powers of selective absorption for mineral elements, they have no special mechanism to exclude injurious elements that may occur in soils.

2. Some plants act as accumulators of particular elements, for example. *Astragalus* sp. of selenium; many monocotyledons, of silicon; the tea plant, hickory and some ferns, of aluminium; and many plants that grow well on acid soils, of manganese and aluminium. Němec has reported the accumulation of gold by *Equisetum palustri* from some soils in Bohemia, and the presence of metallic mercury

in the capsules of *Holosteum umbellatum*.

It should be mentioned also that the needs for trace elements of plants and animals are not coincident, though some of the discrepancies may be due to lack of knowledge. Thus cobalt and iodine are regarded as essential for animals, but have not so far been proved to be so for plants. Again, some plants may accumulate either essential or ' other ' trace elements in amounts that are highly toxic to animals, for example, molybdenum and selenium, but not to the plants.

Historical aspects

Interest in the role of trace elements in the nutrition of plants was beginning to be shown about the middle of last century, about the time when Liebig was expounding his views on the mineral nutrition of crops, based on ash analysis. Thus, Sachs and Knop in 1860, working independently with water cultures of plants, both included iron as an essential constituent of their nutrient solutions.

In France a number of workers used the fungus *Aspergillus niger* in early studies of mineral nutrition problems, and in 1869 Raulin suggested that zinc was probably essential for this organism. In 1897 Bertrand stated that manganese was probably necessary for the functioning of the enzyme laccase, and in 1905, using Aspergillus, claimed that manganese was essential for its growth. In 1911 Bertrand and Javillier claimed that both manganese and zinc were necessary for this fungus and in 1914 Mazé showed that both were essential for a higher plant, maize.

In 1910 Agulhon obtained increased growth by supplying *boron* to a number of crops, including wheat, oats and turnip, and by 1914–15 Mazé regarded boron as an essential element. This view was finally confirmed by Miss Warington at Rothamsted in her work on the broad bean, and the importance of boron for agricultural crops was later shown by Sommer and Lipman (1926) for cotton, buckwheat, and some other crops, and by Brandenberg (1937) for sugar-beet and mangold, and later by other workers for a large range of crops, including swede, cauliflower, lucerne, celery, tobacco, apples and other fruits.

The essential nature and importance of *manganese* for many crop plants were shown from 1922 onwards, notably by McHargue (1922 to 1928) and Samuel and Piper (1928, 1929). The crops included cereals, particularly oats, sugar - beet, peas, sugar - cane and various tree fruits, and ' diseases ' recognised as resulting from deficiency of the element included ' grey speck ' of oats, ' speckled yellows ' of sugar-beet, ' marsh spot ' of peas, ' Pahala blight ' of sugar-cane, and ' Frenching ' of fruit trees.

Bortels (1927) demonstrated that *copper* was essential for *Aspergillus niger*. Diseases of rosaceous species and of citrus, later shown to be caused by deficiency of copper, had been recognised in Florida as early as 1875, and in 1917 Floyd had reported the beneficial effects of copper on diseased citrus trees. In 1931 Sommer proved that copper was essential for sunflower and flax, and in the same year Lipman and Mackinney showed that flax and barley fail to produce seed in the absence of copper. Since that time the range of crops requiring copper has been greatly extended, including cereals, Sjollema (1933), and many fruit crops, Anderssen (1932) and Oserkowsky and Thomas (1933).

The early work of Bertrand and Javillier on the essential nature of *zinc* for *Aspergillus niger* was confirmed by Steinberg (1919), who used new purification methods to prepare his nutrient solutions, and later by Bortels (1927). Working on crop plants, Sommer and Lipman (1926) and Sommer (1928) showed that zinc was essential for sunflower, barley, buckwheat and broad bean, and thus confirmed the early findings of Mazé (1914) for this element. These results were quickly followed by numerous others in connection with diseased conditions of various crops, for example, ' white tip ' of maize, ' little leaf ' of deciduous fruits, and ' mottle leaf ' of citrus.

In 1930 Bortels drew attention to the importance of *molybdenum* in the processes of nitrogen fixation by soil organisms, and in 1937 Steinberg showed that the element was essential for *Aspergillus*. In 1932 Ter Meulen published a paper in *Nature* describing the wide distribution of molybdenum in plants and in 1939 Arnon and Stout showed this element to be essential for the growth of tomato in water culture at the low rate of one part per 100 million. Piper (1940) obtained a similar result with oats and Hoagland (1941) with Myrobalan plum. Since 1941 these results have received ample confirmation for many plants: Anderson and Fricke for pasture plants in Australia, Davis for brassica crops in New Zealand, and Hewitt for many crop plants and Nicholas for micro-organisms at Long Ashton. Deficiencies of this element have also been shown to be of importance in crops in many countries, notably in Australia, and including Great Britain.

The evidence for the essential nature of *chlorine* for higher plants is very recent, though the element, as the chloride ion, was used in the original nutrient solutions of Sachs, and as early as 1862 Nobbe had claimed beneficial effects on plant growth from its use. Since that time many investigators have endeavoured to determine whether chlorine is essential for the growth of higher plants, Pfeffer (1900), Mazé (1919), Lipman (1938), but the final proof of its essential nature was obtained as recently as 1955 by Broyer, Carlton, Johnson and Stout for tomato. The great difficulty in working with this element has been its ubiquitous presence in soils, water, chemicals and the atmosphere. The experiments of these latter workers also showed that *bromine* could reduce the requirement of tomato for chlorine.

In addition to the above trace elements, claims for essentiality micro-organisms have also been made in respect of *vanadium*, *tungsten* and *gallium*, but so far there is no conclusive evidence to show that they are concerned directly with the growth of higher plants.

The functions of trace elements

Knowledge of the special functions of the various trace elements in the metabolic processes of higher plants and micro-organisms is at present very limited and biochemical studies relating to functions would seem to offer a most important field for investigation in the immediate future. It is clear, however, that their main functions are likely to be as catalysts in vital enzyme systems and especially in systems concerned with oxidation/reduction reactions. In these latter reactions trace elements with multiple valencies are likely to play important roles, as has already been shown for *iron* in Cytochrome respiration systems, for *copper* in oxidase systems involving polyphenol constituents, and for *molybdenum* in the nitrate reductase system.

Manganese deficiency chlorosis (above) *and iron deficiency chlorosis* (below) *of sweet cherry*

Points that may be made for the various elements are as follows:

Iron and manganese are concerned in oxidation/reduction systems, sometimes probably in antagonistic roles, and with problems of chlorophyll formation.

For *boron* many functions have been suggested. The subject has recently been reviewed by Gauch and Duggar, who have suggested the main function of boron as 'a specific role in the translocation of sugars '. This view is complicated by the fact that plants suffering from boron deficiency may show severe phloem necrosis. Other suggested roles for boron relate to pollen germination, tissue differentiation, metabolism of pectic substances, regulating supplies of soluble calcium, and water relations in tissues.

Copper may have as its most important function its role in oxidase systems of polyphenol constituents, and it is obviously important in meristems.

Zinc also has been suggested as concerned with oxidation/reduction reactions and, according to Reed and Dufrenoy, with reactions regulating the oxidation of phenolic compounds by catechol oxidase in cell vacuoles. Skoog has also associated deficiency of zinc with the excessive destruction of auxin within the plant.

Molybdenum has been shown by Nicholas and Nason to be an essential metal constituent of nitrate reductase, both in higher plants and in micro-organisms. It also appears to be concerned in nitrogen fixation processes by nodule organisms and to play some role in ascorbic acid systems.

Warburg and Luttgens and Arnon and Whatley have shown that the *chloride ion* can speed up photosynthesis *in vitro*, though it was not apparently essential to the process. Warburg and Luttgens suggested that the chloride ion may function as the essential co-enzyme for photo-chemical reactions in photosynthesis.

Deficiencies and excesses

Although so little is known of the special functions of the trace elements, much information is available regarding the pathological effects that result in plants from deficiencies and excesses of them.

Deficiency symptoms

Iron: The main symptom of this deficiency is always severe chlorosis of the leaves, and the young leaves are always most severely affected. The

leaves may be almost completely bleached or the chlorosis may occur as a mottled pattern in which the veins remain green. Scorching of leaf margins and tips may follow on the chlorotic condition, and young shoots bearing affected leaves often die back from the tips. Fruits may be highly flushed. On some broad-leaved crops, for example, brassicas, the chlorosis develops as a ' marbling ' pattern, and in monocotyledons, for instance, cereal crops, the pattern comprises alternating stripes. Many tree crops, especially rosaceous species, and plants that occur naturally on acid soils, are highly susceptible to the deficiency, but many farm crops are resistant.

Manganese: Symptoms of manganese deficiency vary for the different plants. Chlorosis of the leaves is one of the most common effects to be observed. The chlorotic pattern produced is often quite distinct from that resulting from iron deficiency, the chlorosis developing as V-shaped areas from the leaf margins towards the mid-ribs, and leaving only the mid-rib and areas along the sub-main veins green. Often also the young foliage may remain green when other leaves of the plants are affected, another point of difference from iron.

Special semi-chlorotic patterns are shown by cereal crops: irregular lesions on oats, known as ' grey speck ' disease; intermittent chlorotic streaking in wheat and rye, and a general yellowing with some brown spotting on barley. In some plants the chlorosis first develops as a marbling pattern, the affected areas later becoming necrotic, as in ' speckled yellows ' of beets. Brassica crops also develop ' marbling ' patterns in the early stages. In potatoes and tomatoes the leaves develop brown necrotic spotting patterns, often along the areas of the veins, and there may be some chlorosis. Legumes develop characteristic lesions in the seeds, known in peas as ' marsh spot '.

Boron: Boron deficiency is characterised by a large number of so-called ' diseases ' which render crops either worthless or of very low value. The various conditions have been given descriptive names, such as ' heart rot ' of sugar-beet and mangolds, ' canker ' of table beets, ' brown heart ' or ' raan ' of swedes and turnips, ' hollow stem ' of cauliflower, ' cracked stem ' of celery, alfalfa ' yellows ', ' drought spot ', ' cork ', ' corky core ' or ' corky pit ' of apples, ' hard fruit ' of citrus and ' top sickness ' of tobacco. All these diseases provide evidence of the failure of meristems to differentiate properly, for example, shoot tips, pith and epidermis of stems. The deficient plants often bear highly tinted leaves, which may also show marginal browning, and growths, including leaves, shoots, flowers and fruits, may be severely deformed.

Copper: Deficiency of copper may result in some chlorosis of leaves, but the main effects produced are the dying back of shoots and leaf tips, with in some plants the development of deformed shoots and in some species, for example ' Prunus ', severe gumming. Leaf die-back is often followed by defoliation in a basipetal direction, and shoot die-back by the development of adventitious shoots at lower levels, for instance excessive tillering in cereals and ' suckering ' in trees. In instances of severe deficiency, fruiting and grain formation may be totally suppressed. The special features of this deficiency have given rise to the names ' summer die-back ' of apples, ' exanthema ' of citrus, and ' wither tip ' disease of cereals.

Zinc: The main effects of zinc deficiency are chlorosis, the restricted development of leaves, which remain small and narrow, and the progressive shortening of the internodes of shoots, which in extreme instances results in the formation of clusters of leaves resembling rosettes. In some plants the leaves may also develop purple tints, as in tomato and wheat. Some descriptive names used are ' white bud ' of maize, ' mottle leaf ' of citrus, ' rosette ' and ' little leaf ' of fruit trees, and ' sickle leaf ' of cacao.

Molybdenum: In tomato and brassicas, deficiency of molybdenum may result in chlorotic mottling of the leaves where nitrates are given as the source of nitrogen to the plants. In these plants there may be also considerable incurling of the leaf margins. Most plants exhibit marked leaf effects, showing in the early stages areas of thin lamina tissue which dry out and become necrotic. In cauliflower, lamina development may eventually become suppressed, giving rise to the condition known as ' whiptail '. Curd formation is also suppressed and the growing point may die. In the tomato the older leaves are the most severely affected, and the shoots may continue growth. In citrus the leaves become highly tinted, gum spots are formed on the under surfaces and the shoots die back. In leguminous plants the deficiency may show as a deficiency of nitrogen, since the nodule organisms fail to fix enough nitrogen for the plant's requirements. When sufficient nitrogen is supplied to legumes and molybdenum is deficient, the plants then show symptoms similar to other plants, that is, the development of necrotic leaf areas followed by total collapse and death.

Chlorine: Observations have been reported only for tomato: the symptoms comprised wilting of the leaf tips, followed by chlorosis, bronzing and necrosis of leaflets in a basipetal direction.

Excess symptoms

Iron: Excess of iron may produce brown lesions on the leaves and induce deficiencies of manganese and phosphorus.

Manganese: The effects of manganese excess are to induce a deficiency of iron and to produce brown blotchy lesions in leaves, petioles and stems.

Boron: Excess boron in plants tends to accumulate in the older leaves, which develop marginal and interveinal necrosis. Severe injury may result from quite small excesses.

Copper and zinc: Excesses of these two elements tend to induce a deficiency of iron, the condition being evidenced by severe chlorosis and necrosis of the leaves.

Molybdenum: Plants appear to be able to withstand large amounts of molybdenum above their actual requirements; hence there is little experience of the injurious effects of excesses. In pot experiments Miss Warington observed the development of golden and reddish-yellow tints and the formation of blue granular accumulations in *Solanum* species, which appeared to be tannin-molybdenum and anthocyanin-molybdenum compounds.

Chlorine: Excess effects of chlorine are often apparent on crops susceptible to chloride injury where heavy dressings of chloride-containing fertilisers have been applied. The main effects are marginal and interveinal leaf browning, often followed by premature defoliation. The scorch effects may be mistaken for potassium deficiency.

'Multum in Parvo'

Probing the secrets of plant life

A symposium on 'Trace Elements in Soils, Plants and Animals', attended by a number of distinguished scientists from overseas, was recently arranged by the Agriculture Group of the Society of Chemical Industry at Bristol. In spite of the complexity of the subject of plant nutrition, the papers all came in for prolonged discussion. Below is given a summary of the papers presented at the conference.

Trace Elements and Crop Production in the Tropics *by R. A. Webb (A.R.C. Unit of Plant Nutrition, Long Ashton).*

Increasing attention is being given to the use of fertilisers in tropical agriculture. Following usual European practice, attention has been focused on nitrogen, phosphorus and potassium, singly or in combination. *This preoccupation with N, P and K has led to some misinterpretations of results and has tended to restrict thought and experimentation. Spectacular responses have been obtained with NPK fertilisers in some trials, but it is rare to find the yields reaching maximal values, even with massive applications of fertiliser. Very often quite small doses give as good results as much larger amounts.*

In recent years the remaining nine or ten elements other than N, P and K known to be essential for plant growth have begun to receive attention. Ferrand, Bachy and Ollagnier reported increased fruit production in oil palms due to Zn, Cu, Mn, B and Fe applied along with a NPK mixture which had itself a positive effect. Joshi and Joshi record rice yields being increased by one-third following the application of copper sulphate, while the application of copper plus manure gave a 77% increase over a manured crop yield. As a result of a questionnaire circulated to workers in Africa, Schutte was able to report trace element deficiencies in practically every territory in tropical Africa. Deficiencies have also been reported from other tropical territories.

Any trial which does not take into account the possible effect of *all* the essential elements must be regarded as incomplete, open to misinterpretation, and perhaps unrepresentative of the true potentialities inherent in the situation. Experiments have shown that major element responses can be limited drastically by trace element deficiencies and *vice versa*, and it is possible that a number of deficiencies may exist concurrently and that the lack of response to the addition of a particular element may be due to another simultaneous deficiency. One is faced with the necessity of testing a large number of mixtures of increasing complexity, looking for relatively high order interactions. For diagnostic purposes such a procedure is too unwieldy for general use.

If a reasonably balanced complete fertiliser, containing all known essential elements, were used as a standard, comparisons might be possible between the response to the complete fertiliser and responses to deficient mixtures prepared by omitting each element in turn from the complete mixture. The technique of preparing the mixtures has been worked out by Hewitt and used by him to produce visual deficiency symptoms for the essential elements in a variety of test plants.

The method was tried out in pots in the Gambia in 1953–54 using field soils taken from plots on the Yundum Experimental Farm. The complete nutrient mixture used was one which has given good results with many crops on purified sand. It had the following composition:

KNO_3	10.1 g.
$Ca(NO_3)_2$	16.4 g.
$NaH_2PO_4,2H_2O$ ..	4.2 g.
$MgSO_4,7H_2O$	7.4 g.
Ferric citrate	0.5 g.
$MnSO_4,4H_2O$	44.6 mg.
$CuSO_4,5H_2O$	5.0 mg.
$ZnSO_4,7H_2O$	5.8 mg.
H_3BO_3	37.2 mg.
$(NH_4)_6Mo_7O_{24},4H_2O$ ..	0.7 mg.

These amounts were dissolved in 20 l. of water for application at the rate of 1 l. per day to each 11-in. pot of adult plants. The chemicals were

The Agricultural and Horticultural Research Station, Long Ashton

purified as described by Hewitt and water of high purity was used throughout. Controls which received only water were also set up. Judging not only by the weights of plant or crop produced, but also by the appearance of visual deficiency symptoms on the plants, it was concluded that the method indicated the probable existence simultaneously of several mineral deficiencies capable of restricting yield.

The omission of N or P had the most marked effects, followed by those with omission of K or S. The results varied with the test plant, groundnuts being unaffected by the omission of N in the presence of all other elements. As far as the trace elements are concerned, the omission of either Mn, Cu or Zn affected the growth of maize. The omission of Mn or Mo affected the growth of cabbage, while lack of Mo had a very marked effect on lettuce. All the soils tested indicated the probable presence of multiple deficiencies involving four or more elements, the omission of which from a fertiliser mixture could reduce the effectiveness of the fertiliser by 50% or more.

Trace Element Uptake by Sweet Vernal in Relation to Mineralogy and New Zealand Genetic Soil Types *by M. Fieldes and N. Wells* (*Dept. of Scientific and Industrial Research, New Zealand*).

Trace elements essential for the growth of animals and plants have come principally from igneous rocks.

The value of soil classification as a basis of research investigations is illustrated by correlation of measurements of molybdenum uptake by sweet vernal with molybdenum content of topsoils, molybdenum retention, and clay mineralogy of a wide range of New Zealand soils.

The grass sweet vernal (*Anthoxanthum odoratum* L.) was selected as a plant indicator of element availability because it is widespread and can be obtained from sites which have not been top-dressed, on both fertile and infertile soils under a wide climatic range. Sweet vernal is found on all major soils of New Zealand except extremely saline gley soils and drier brown-grey earths. It is distributed on all New Zealand main islands, between latitudes of 34½° S. and 47° S., from sea level to altitudes of 4,000 ft., under rainfall ranging from 18 in. to over 100 in. per annum, and at average mean temperatures ranging from 42°F to 60°F. Samples of the grass at the flowering stage are analysed for as many elements as possible; spectrographic analysis of the plant ash is used for determination of calcium, sodium, magnesium, copper, manganese, iron, barium, strontium, aluminium, silicon, titanium and molybdenum. Spectrographic analysis of a concentrate from an oxine precipitate is used for molybdenum, cobalt, gallium, vanadium, zinc, germanium, nickel, beryllium, chromium, tin, lead, silver, thallium and titanium. A flame photometer is used to determine potassium, and phosphorus is measured colorimetrically.

In recent years it has been shown that in some districts of New Zealand small applications of molybdate result in marked growth responses in pastures and crops.

Molybdenum as an Essential Plant Nutrient for Higher Plants *by E. J. Hewitt* (*Long Ashton Research Station, Bristol*).

All molybdenum-deficient plants grown with nitrate have shown very similar symptoms. These include chlorosis (yellow-green, yellow or orange mottling of leaves) followed by marginal curling, wilting necrosis and leaf withering, often immediately preceded by water-soaking of some areas by escaped cell fluids. Rapid and total recovery is possible on adding molybdenum at any time.

These symptoms are associated with low yield, often less than 5% of normal plants, and with the accumulation of nitrate which may attain more than 15% of total dry material. The contents of protein, total soluble organic nitrogen and chlorophyll are abnormally low.

In one group of plants, the brassicas, other symptoms associated with molybdenum deficiency may also occur. These are ' whiptail ' in cauliflower and broccoli. In cauliflower the symptoms start always as one or more small rounded translucent areas between major veins near the midrib of one or two young leaves (usually 6–15 cm. long): these areas become yellow or totally chlorotic, necrotic and rapidly perforate. As the leaf continues to expand they leave enlarged irregular holes, and as the leaves elongate the margins become wavy, irregular and defective. Leaves with little or no lamina are finally produced but they may still elongate considerably, producing the ' whiptail ' effect. The growing points of the youngest leaves and of the stem apex are finally killed. They lose their cell contents and dry up, leaving smooth, rudimentary stumps. Old leaves, by contrast, remain attached to the plant and appear turgid, green and normal for several weeks, except for a tendency to crack easily. In acutely deficient plants flowering is suppressed and reproduction is totally prevented.

In order to establish the requirement for molybdenum by plants grown in the absence of nitrate or with alternative sources of nitrogen, experiments have been made with cauliflower and tomato grown in sand or water culture, using several different nitrogen sources with or without added molybdenum.

It is evident that mottling, withering and loss of chlorophyll in molybdenum-deficient plants are associated with the provision and probably the marked accumulation of unassimilated nitrate and do not occur when other nitrogen sources *only* are given.

Role of Trace Elements in the Nitrogen Metabolism of Plants with Special Reference to Micro-organisms *by D. J. D. Nicholas* (*A.R.C. Unit of Plant Nutrition, Long Ashton*).

Iron, copper, zinc, manganese, molybdenum and boron are known to be essential for the growth of green plants. More recently the following additional nutrient requirements have been reported—chlorine for many higher plants, sodium for a blue-green alga *Anabaena cylindrica*, and vanadium for *Scenedesmus obliquus*.

Two approaches have been used to establish if a mineral nutrient is essential for plant growth—(*a*) its omission from the diet resulting in a reduction in growth which can be remedied only by returning the nutrient to the plant in a readily available form, (*b*) establishing a role for the metal in intermediary metabolism.

In recent years trace metals have been found to be associated with a number of flavo-proteins, some of which are key enzymes in the nitrogen metabolism of plants. Thus molyb-

Whiptail disease in cauliflower caused by deficiency of molybdenum

denum is a constituent of nitrate reductase which catalyses the reduction of nitrate to nitrite in bacteria, fungi and green plants.

Trace metals are known to be essential for the fixation of atmospheric nitrogen in free living bacteria, *e.g. Azotobacter* and *Clostridia*, and in root nodule bacteria, *e.g. Rhizobia*.

Some Nutrient Interactions Affecting the Growth of Pasture Legumes in Acid Soils *by E. G. Hallsworth, E. A. N. Greenwood and J. Auden* (*School of Agriculture, Sutton Bonington, Notts.*).

Elements required in large quantities, such as calcium and potassium, are never present at toxic levels; those elements of which the plant requires only trace quantities (the micronutrients)—notably manganese, copper, and zinc—give rise to striking symptoms at both deficiency and toxicity levels. These deficiency or toxicity symptoms are accompanied by reductions in growth *rate* and in the subsequent yield of the crops produced.

Between the levels of supply corresponding to deficiency or toxicity symptoms lie those permitting optimum growth. These levels are not fixed, even for one plant species, and it has become increasingly obvious that considerable intereaction between the nutrients may take place. That is to say, a level of supply of a nutrient which produces optimum growth with one group of other nutrients at a certain level may lead to deficiency or even to toxicity should the level of one of these others be varied considerably. The availability of the micro-nutrients to the plant has been found to vary widely with the acidity of the soil. This effect is particularly marked with molybdenum and manganese. For molybdenum the availability falls drastically at high acidity, whereas for manganese the change is in the opposite direction and manganese deficiency has most commonly been associated with alkaline soils.

For clover and lucerne very low calcium levels lead to drastically reduced growth, even at low concentrations of manganese and aluminium, but lupin plants were only slightly stunted. In lucerne, there is a general stunting of growth and the leaves are paler with higher levels of aluminium. The lower leaves show a purple coloration and in some cases the petiole collapses; there is also a nipping and withering of the upper leaves. With clover the symptoms are not so marked—the leaf surfaces showed blotches and speckles and the margin of the leaf became withered. With lupin, there were no toxicity symptoms and the plants actually made better growth than those receiving less aluminium.

A direct effect of *p*H on the growth of both white clover and lucerne was found which is distinct from the influence of manganese and aluminium, but it is operative only at the *germinating seedling* stage.

Another aspect of the soil acidity problem is the insidious occurrence of single and multiple deficiencies not severe enough to produce clinical symptoms. Copper is of interest in this respect as in light-textured acid soils it is mobile and may be largely leached out of the profile. Using sand culture and subterranean clover, *Trifolium subterraneum*, as the test plant, certain levels of copper may cause a very large reduction in growth both directly and by a strong intereaction with molybdenum, even though the growth produced was free from the symptoms of deficiency.

Trace Element Uptake in Relation to Soil Content *by R. L. Mitchell, J. W. S. Reith and I. M. Johnston* (*Macaulay Institute for Soil Research, Aberdeen*).

Plant uptake cannot be related directly to the total trace-element content of a soil. Even in the most acute instances of deficiency there is more than enough of the element in the soil to provide adequately for the crop if it were all readily available. A pasture herbage containing sufficient cobalt to sustain ruminants in a healthy condition need reduce the cobalt content of the surface soil by no more than 0.0005 p.p.m., yet deficient herbages occur on soils containing several parts per million total cobalt.

In view of the changes in the composition of plant samples which can arise at different times of sampling, there will probably be general agreement that, once the factors involved are appreciated, the most satisfactory long-term picture of trace-element status of the vegetation carried by any particular soil should be obtainable from examination of the soil itself.

Investigations in progress have demonstrated the effects of agricultural practice on plant composition, as, for instance, the difference between pasture herbage regularly cut and that allowed to grow to maturity. One objection to sampling a grazed herbage is the difficulty of avoiding soil contamination, and a second that it is what the animal has rejected that is available for sampling.

Numerous factors affect the uptake of trace elements by plants and lead to variations in the distribution within the plants themselves. All serve to

complete nutrient *complete nutrient less molybdenum.*
Savoy cabbages, 6–7 weeks old.

complicate the diagnostic assessment of the trace-element status of a soil by plant analysis. Under poor drainage conditions the extractable contents of many trace elements in soils are increased, and in certain instances, notably cobalt and nickel, there is a corresponding increase in plant uptake. The relative contents of trace elements in the constituent species of a mixed herbage are not constant.

Iron Chelates* in Plant Nutrition *by R. C. Bould* (*Long Ashton Research Station, Bristol*).

Iron chelates are effective in correcting iron chlorosis in plants even though the iron is present in non-ionised form. The evidence, so far available, indicates that the iron chelates of polyaminopolycarboxylic acids (*i.e.* Fe-EDTA etc.) are the most effective carriers of iron for nutrient culture work especially at *p*H values above 7.0. The indications are that these iron complexes are absorbed in molecular form and that the iron is subsequently released by photo-reduction and is thus made available to the plant.

Iron chelates at present commercially available have serious limitations when used as soil dressings on calcareous soils as they break down rapidly—the iron in the complex is replaced by calcium and is adsorbed by the clay—so that there is no plant response. In view of this instability some workers have tried to apply them as foliar sprays using a wetting agent; new chelates, now under trial, appear to be more promising. If these compounds can be produced at a reasonable price, it should be possible to control chlorosis of plants growing in calcareous clay by soil dressings.

*Chelate: a claw (Greek)—a descriptive name for the iron complexes of polyaminopolycarboxylic acids. The iron is bound to the molecule, but not in ionised form, *i.e.* not as a salt.

The Application of Chromatography to Nutritional Problems in Plants *by A. H. Williams* (*A.R.C. Unit of Plant Nutrition, Long Ashton*).

Some of the micronutrients are known to be components of enzyme systems and can participate in electron transfer reactions by virtue of their alternative valency states.

Only storage and structural materials, end products of metabolism, or those whose rate of reaction is slow in comparison with their rate of formation will accumulate and be easily detected. Important intermediates and reactive substances will be present only in very small amounts since the reactions by which they are utilised are rapid and their equilibrium concentrations consequently low. The study of such transient intermediates may be helped by their accumulation under abnormal conditions such as nutritional deficiency: the nutritional status of plants may be reflected in the accumulation or disappearance of some metabolic intermediate.

Visually, the response of a plant to nutritional deficiency is variation of growth habit, general stunting, changes in leaf pigmentation such as chlorosis, and premature senescence perhaps leading to early death. Some of the changes in the organic constituents which can be inferred from these symptoms are reduction in the formation of structural materials, proteins, carbohydrates, and of chlorophyll, derangement of metabolism leading to tissue breakdown and the premature appearance of products such as anthocyanins, usually associated with senescence.

The first set of experiments described relates to variations in the free amino-acid content of the leaf of cauliflower grown under conditions of molybdenum deficiency with various forms of nitrogen supply. The variations induced by change of nitrogen source emphasised the need for some knowledge of the effect of changes in the supply of major nutrients, and so the second set of experiments consists of a more general survey of the simpler organic constituents of tomato leaf and their response to variations in nutritional status with regard to the major nutrients.

The Use of Paper Chromatography in the Separation of the Valency States of Biologically Important Metals *by H. M. Stevens* (*A.R.C. Unit of Plant Nutrition, Long Ashton*).

The role of trace metals in cell metabolism has been investigated in recent years, especially of those whose valency states function in electron transfer in biochemical systems. Metals which are essential constituents of enzyme systems in certain instances undergo valency changes during enzyme action.

Pure solutions of metals in various valency states were supplied to micro-organisms grown in pure culture. Certain properties of the systems such as enzyme activity, the amount of metal taken up by the organism from a given valency solution etc., were then determined.

The Complexing of Copper with Natural Components of Fruit *by C. F. Timberlake* (*Long Ashton Research Station, Bristol*).

The concentrations of copper, zinc and particularly iron in apples have

been found to be much higher in the peel than in the flesh of the fruit. This is of interest since the peel is the source of most of the physiological activity of the apple and also contains one-third of its protein nitrogen.

Traces of copper in apple juice exist largely as cupric ions in equilibrium with copper complexed with other juice components. The main complexing agents are organic acids, amino acids and the phenolic compounds and the degree of complexing depends upon relative concentrations and the *p*H.

Dietary Factors Influencing Copper Utilisation by the Animal *by C. F. Mills* (*The Rowett Research Institute, Bucksburn, Aberdeenshire*).

Studies on the stability and solubility of organic complexes of copper in herbage and the utilisation of these compounds by the rat and sheep are described and the results discussed in relation to the suggestion that certain stable, soluble complexes may be directly absorbed through the digestive tract mucosa.

The Trace-Element Contents of Herbage Plants with some Reference to their Availability to the Animal *by A. Thompson* (*King's College, University of Durham*).

Widespread disorders in livestock attributable to the deficiency or excess of a particular trace element have, in general, never been a feature of British agriculture. Indeed, the belief was widespread that most British pastures were able to meet any demands for the minor elements which might be made upon them.

In recent years, however, emphasis upon increased production has brought into prominence the problem of sub-optimal levels of mineral intakes as against those so low as to produce clinical symptoms. The indisputable improvements in the health of stock brought about by the use of mineral mixtures is in itself some confirmation of the view that feeding stuffs, including grass and grassland products, do not always meet the demands of the animal for the inorganic elements, both major and trace.

Analysis of grasses, legumes and herbs indicates that the last two are, in general, better sources of the trace elements than the first; there are, however, appreciable differences within groups. Two herbs, *viz.* plantain and chicory, are exceptionally rich in trace elements, as in the major elements.

The effect of varying manurial treatments on the trace-element content of individual herbage species is illustrated. Certain typical moorland plants are shown to contain very large amounts of manganese, and common heather in particular to be a good source of copper and cobalt.

Cobalt Deficiency in Sheep in Herefordshire *by A. D. Osborne* (*University of Bristol, Veterinary Laboratory, Langford*).

A pining condition of lambs associated with a deficiency of cobalt in the soil in an area in North Herefordshire is described. Some evidence is presented that the symptoms are more marked when the temperature and rainfall combine to give a generous growth of pasture during the period of risk.

This investigation into cobalt deficiency was made as a result of the observation on a single farm that a proportion of lambs, varying from year to year, failed to thrive during the summer and autumn.

Chemical analyses of soils carried out on a large number of farms in Herefordshire and adjacent counties revealed that in a high proportion the cobalt content was equal to or lower than the critical level.

The soils on all the farms sampled were relatively heavy clay from the old red sandstone formation. The deficiency condition did not appear to be serious in the southern part of the county where the clay was lighter. Experiments were carried out to determine the response of lambs, in terms of weight gain, to the provision of cobalt sulphate given as a drench during the summer and autumn. This resulted in a greater response from the males than the females.

The Incidence and Control of Cobalt Deficiency Under Varying Soil and Pasture Conditions in Connemara, Co. Galway *by L. B. O'Moore* (*Veterinary Research Laboratory, Department of Agriculture, Dublin*).

Two separate incidences of cobalt deficiency in grazing stock are described, *viz.* ' galar truagha ' in cattle in the coastal area on a soil of calcareous sand, and ' summer pine ' in sheep, especially recently weaned lambs, pastured on specific tracts of acid peat in the inland hill area. The traditional method of avoiding these malnutritional syndromes is systematic transference of stock to different grazing areas. Controlled experiments on supplying cobalt to stock showed that drenching the animals with aqueous cobalt sulphate solution fortnightly is preferable on calcareous sandblown pastures, and top-dressing the pastures with cobalt sulphate is advocated for acid peatland.

Effect of Zinc, Calcium and Phosphorus on the Skin and Growth of Pigs *by D. B. Bellis and J. McL. Philp* (*Unilever Ltd., Sharnbrook, Bedford*).

A dermatitis and growth syndrome occurring in 8–16 week-old pigs fed dry *ad lib.* on proprietary or home-mixed diets has been investigated. The disease was aggravated by increased calcium and decreased by reduced calcium and increased phosphorus levels in the diet or by wet restricted feeding. Supplementation of the diet with 100 p.p.m. of zinc prevented or alleviated the condition with considerable increase in growth rate and efficiency. Zinc availability is apparently inversely related to that of calcium in the diet.

Photos : Long Ashton Research Station.

Technical News

Articles in the July issue of other journals of the Leonard Hill Technical Group include the following :

Corrosion Technology.—' Prevention of Corrosion by Water Treatment ' by T. B. Fielden, A.R.I.C.; ' The Role of Corrosion Inhibitors in Water Treatment ' by E. L. Streatfield, B.SC., F.R.I.C., M.I.CHEM.E.

Atomics.—' The Future of Nuclear Power ' by Sir Christopher Hinton; ' A New Type of Atom-smasher '; ' Canada's Uranium Prospect ' by T. H. Skeet.

Dairy Engineering.—' Frozen Milk by Ultrasonics ' by W. G. Wearmouth ; ' Revised Ideas on Bottle-washing Detergents ' by G. B. Beattie; ' Instruments in the Dairy ' ; ' The Dairy Industry in Czechoslovakia ' by Ing. Vaclav Knez.

Chemical & Process Engineering.—' Pulp Products from Poplar '.

Recent Advances in Residual Pre-emergence Herbicides

PAUL BRACEY

(Consultant biologist, Mirvale Chemical Co.)

A pre-emergence herbicide is one which is sprayed before the emergence of the crop, or before the emergence of the weeds, or before the emergence of both. Advantage can be taken of the weeds which appear before the crop by using a non-selective contact herbicide. The essence of this treatment lies in the pre-emergence herbicide acting where it falls and then rapidly disappearing from the scene of action. This article deals with certain new compounds which are not rapidly destroyed in the soil and are thus described as residual pre-emergence herbicides.

CLASSIFICATION amongst selective herbicides is not easy. It is well understood that a selective herbicide has the ability, by one way or another, to destroy weeds in a crop to which it is harmless. We generally understand that the description 'pre-emergence' is applied to a herbicide which is sprayed before the emergence of the crop or before the emergence of the weeds, or before the emergence of both.

Non-residual pre-emergence herbicides

Advantage can be taken of the weeds emerging before the crop. In these circumstances, non-residual, non-selective pre-emergence herbicides can be used. In this class are found both chemical and physical treatments, which work by 'burning off' the foliage of the weeds; examples of this type are the flame gun and sulphuric acid. The latter two are probably the most effective, but the group includes a very wide range of materials such as P.C.P. (pentachlorphenol), tar acids, tractor vaporising oil, common salt, sodium chlorate, sodium arsenite, or any other compound or instrument which can cause a burning, scalding or wilting effect on weed foliage. Various mixtures of such materials may be discovered from time to time and shown to have considerable effect (especially if mixed with M.C.P.A.) in certain crops.

In general, these treatments are non-selective with the notable exceptions, for example, of the use of sulphuric acid as a selective weed-killer in onions, of sodium arsenite to destroy weeds associated with rubber, and of paraffin as a selective weed-killer in carrots. The chemical compounds included in this class are generally harmful to mammals and damaging to adjacent crop plants, resulting from drift or from direct spray. Compounds like sodium chlorate can easily be demonstrated as having considerable herbicidal effects at very low dosages as a pre-crop emergence herbicide in bulbs, for example, but like the other compounds listed above, have only contact effects.

It will be appreciated that the essence of such treatments lies in the pre-emergence herbicide acting where it falls and rapidly disappearing from the scene of action. If such were not the case, of course, emerging crops would be equally damaged by the material remaining in the soil.

Residual pre-emergence herbicides

This article is concerned with the description of certain relatively new compounds, which are not rapidly destroyed in the soil and are thus described as residual pre-emergence herbicides. They have the advantage, therefore, of being able to deal with weeds which emerge after the application of the herbicide. They are more safe to handle than many of those listed previously. Moreover, one of the compounds described has the unique property of being applied in a form where it is harmless to the foliage of all plants and is only converted by the soil to an active herbicide.

The use of these herbicides alone or in admixture with each other has made possible the use of chemical weed control in orchards, farms and market gardens with little or no hazards from drifting spray. In various agricultural or horticultural regions of the world, these developments may prove to be of the greatest interest and value.

2:4-D.E.S.

An outstanding contribution to this new phase of chemical weed control was the discovery of 2:4-D.E.S. by King in the U.S.A. In a series of classical experiments, King showed that sodium 2:4-dichlorphenoxyethyl sulphate (2:4-D.E.S.) had no effect when applied to the foliage of established plants, which were otherwise sensitive to 2:4-D, but, when applied to the soil, bacteria broke up the 2:4-D.E.S. to release the active principle, 2:4-D. The latter killed germinating weeds of both broad leaf and grassy plants, by their absorption of the 2:4-D into the seedling root. Furthermore, it was shown that this herbicidal activity to germinating seeds could persist in the top soil for several weeks.

This important discovery led logically to the realisation that chemical weed control might be possible in many important crops which were normally damaged severely by 2:4-D itself. The possibility of residual pre-emergence control of weeds by the application of 2:4-D.E.S. to clean soil, *i.e.* devoid of established weeds,

has spread amongst American growers and is of increasing interest to growers in the U.K.

Experience with the compound on farms and market gardens by field trials has shown that the original laboratory indications that 2:4-D.E.S. might be suitable for all crops in all situations, have had to be modified. While a wide range of established crop plants has been sprayed with 2:4-D.E.S. without harm, including top and soft fruit, beans, asparagus, bulbs, nursery stock, roses and many other perennial herbaceous plants, certain other plants were damaged by absorption of the active material through the roots, although they were unaffected by the spray drift on to their leaves. These more susceptible plants include a few weeds and certain crops, *e.g.* creeping thistle, bindweed, and also cabbage, cauliflower, lettuce and celery.

Once it had been shown that weeds could be controlled by destroying their seedlings as they germinated, careful investigations were actively pursued in the laboratory and plantations. During the last five years, workers in different parts of the U.K. have been gaining experience with 2:4-D.E.S. The result of this work is that much more is now known about the conditions which are required for the best results and, taking strawberries as an example, these may be summarised as follows:—

(1) The soil must be free of established weeds.

(2) The application is best made when the soil is wet and warm.

(3) If the soil is clean but dry, it should be hoed or cultivated not more than one day before spraying.

(4) 2:4-D.E.S. should be applied at rates lying between 4 lb. and 6 lb. per acre, in a volume of water of preferably not less than 50 gallons per acre, in order to obtain adequate soil coverage. Applications may be repeated at intervals of six to eight weeks during the growing season.

A strawberry plantation is probably most effectively weeded, with the aid of 2:4-D.E.S., by making the first application immediately after the cleaning of the plantation, following harvest. The treatment can be repeated six to eight weeks later, when the plantation can be expected to remain clean until the following May or June. A spring treatment, just prior to the opening of flower trusses in mid-May, may be justified in certain seasons. It follows from these typical recommendations that 2:4-D.E.S. is best incorporated in the normal routine of soil preparation.

C.I.P.C.

This is one of the substituted carbamate family of herbicides. It appears to be selectively toxic to meristematic tissue and so kills the growing points. For some unknown reason, this effect does not occur with groundsel (*Senecio vulgaris*). This mode of action can also be utilised by strawberry growers to reduce to manageable proportions the number of runners produced in fruiting plantations. It is a particularly effective killer of chickweed and annual grass seedlings.

C.I.P.C. appears to be more active and more persistent at low dosage and low temperatures than the substituted ureas and it is, thus, particularly well suited for application to narcissi and other crops growing during the cold, dormant season. The damage or checking caused by C.I.P.C. to crops, like strawberries or herbaceous perennials, may be avoided by using the herbicide in a pre-planting treatment, during the dormant season, or by formulation as a granular material which readily rolls off the foliage. Thus, strawberries may be safely sprayed during autumn or winter, with as much as 2 lb. per acre of C.I.P.C., with no noticeable crop response.

This feature of long-lasting herbicidal action in the cold season may be useful also in cane and fruit tree plantations, by allowing applications during leafless periods of the year.

C.I.P.C. has a special position as an additive to 2:4-D.E.S. The normal application rate of C.I.P.C. is approximately 2 lb. of active material with 4 lb. 2:4-D.E.S.

P.D.U.

P.D.U. is a member of the substituted urea family of herbicides. It is the most water soluble of those substituted ureas which are well known in commerce, and its persistence is the least of these. The range of weed species that it attacks is very wide. At very low application rates, it persists for only a few weeks in the soil. The dangers to the crops involved in the use of its chlorinated relatives are, thus, not present in the case of P.D.U. At dosage rates as low as half a pound of active material per acre, it possesses a residual life of about four weeks in the summer. At this dosage it is tolerated by a wide range of crop plants. Commercial formulations, combining 2:4-D.E.S. with P.D.U. are likely to prove of great value to horticulturists in the near future.

Mixtures of 2:4-D.E.S.

Experience has shown that situations arise, especially in perennial crops, where it may not be possible to hoe immediately before spraying 2:4-D.E.S. It has also been found that, at low temperatures and in certain soil types which may be deficient in bacterial flora, the conversion of 2:4-D.E.S. to active 2:4-D may be much delayed. In such conditions, even as much as 50 lb. per acre of D.E.S. has failed to control all weed germination immediately after application.

In order to overcome such adverse conditions, it has been found, by field experiments in a wide range of soil types and conditions, that the addition to 2:4-D.E.S. of certain substituted carbamates or substituted ureas, such as C.I.P.C. or P.D.U. in low dosages, has given very marked improvement in pre-emergence weed control by more sure destruction of weed seedlings immediately after application.

It will be seen from remarks which have been recorded so far in this article that the attack by 2:4-D.E.S. against chickweed can be much improved by the addition of C.I.P.C., for instance, whilst the control of groundsel, which is not controlled by C.I.P.C., is achieved by the addition of P.D.U.

Soil erosion

It has been indicated earlier in this article that the purpose of residual pre-emergence herbicides is to keep clean ground clean. No reference has been made to the complications caused by the presence of such difficult perennial weeds as couch grass (*Agropyron repens*), but it is anticipated that herbicides may soon be available for eradicating even couch grass from plantations of perennial crops.

It can be seen that, by means of two or three sprays per year, the

grower may find his soil surface kept virtually bare except for his crop plants. Furthermore, there are already indications that the use of 2:4-D.E.S. for one season is followed in the next season, without further spraying, by a marked reduction in the numbers of germinating weeds. Repeated use of these residual pre-emergence herbicides for several years may, therefore, lead to a situation where a field might be as free of viable weed seeds as steamed glasshouse soil. In areas of heavy rain and steeply-sloping ground, this situation might present problems of soil erosion.

Contour cultivation is recognised as the approved method for reducing soil erosion on sloping land, but it is also possible to use residual selective pre-emergence herbicides in such a way as not only to allow the formation of a weed cover during particular periods of the year, but also to select, although in a limited way at present, the type of weed desired.

For instance, continuous use of low dosages of P.D.U. results in the ultimate formation of a pure stand of speedwell (*Veronica spp.*) when spraying is stopped; C.I.P.C. is followed by groundsel (*Senecio vulgaris*) and 2:4-D.E.S. by annual grasses and chickweed. In other climates the weed selection and succession would evidently be different.

A logical development of this phenomenon is that, once a pure stand of a certain grass, for example, was established, it would be theoretically possible to prevent the invasion of any other plant species. This is a feature which might be of practical value in orchards or other situations where a particular ground cover was desired.

The selection of the weed cover ultimately desired by the grower would probably be affected by several factors, *e.g.* the nurseryman might want a thick winter cover of chickweed to prevent frost making the ground too hard to permit lifting of plants for sale; whereas the bulb grower might select speedwell as a low growing plant (not black-listed as an alternate host for bulb eelworm), which would hold the top soil together, while not growing too tall to interfere with flower-cutting.

Discussion

In conclusion, therefore, we may state that in 2:4-D.E.S., C.I.P.C. and P.D.U. the grower has compounds which may be used individually or in various combinations (including all three together), which may help him to keep his crops and his land free from weeds without fear that spray-drift would damage adjacent crops. He may achieve this, furthermore, with the knowledge that the better the conditions are for weed germination the better will his treatments work.

Advances in formulation, more especially perhaps as granular preparations, have brought very close the day when the herbicides may safely be put into the hands of the home gardener in a ready-to-use form, to serve as a welcome substitute for the hoe.

Although much as been achieved, much more work has to be done to establish in a precise manner the value and limitations of these new compounds and new techniques in the nursery, market-garden and farm, under different climatic conditions.

Scrub Clearance on a Pineapple farm in South Africa

This British-made International BTD-6 is being used on the pineapple farm of a famous South African jam and canned-fruit manufacturer. It is operating with an unusual American dual-purpose tool, the toolbar dozer combination. With the blade, as seen, it is used to clear dense virgin brush, but with the frame reversed a heavy toolbar is fitted at the rear, taking either two subsoiler attachments or a set of cultivator tines of the coil type

Soviet Grain Production

Even allowing for exaggerated reports, 1956 appears to have been a very successful year for agriculture in the Soviet Union. The question is whether this improvement in the harvest will be maintained.

Following the serious situation in 1953, expansion in the output of machinery and fertilisers was speeded up and in 1954 a drive was launched to use for grain production vast areas of the steppelands of Siberia and Kazakhstan. Already 87 million new acres have been brought under cultivation.

The fertility of these virgin lands is now at its maximum, and so is the proportion of them sown to grain. Soon, if soil structure is to be preserved, it will be necessary to allow land to lie fallow or else to sow grasses.

The climate, too, plays a very large part in deciding the size of the harvest in the Soviet Union and usually there is a drought somewhere which reduces the total harvest. In 1956 this did not occur; on the contrary, the semi-arid steppelands, east of the Urals, where these virgin lands are situated, received abnormal rains.

Crops in South Africa

(*From Our South African Correspondent*)

THE phenomenal growth of the banana industry in the Union during the past few years may be halted unless South Africa can build up an export market, according to leading growers in the Transvaal lowveld. South Africa, according to them, is on the brink of satisfying its own banana requirements, but as there have been such heavy plantings other markets must now be explored. During 1956 the first shipment of export bananas from this area arrived in London in good condition.

Apart from the Natal banana industry, which was established many years ago, banana culture elsewhere in the Union is only a recent venture. A few years ago the Transvaal lowveld was found to be ideal for bananas and the plants are now growing by the mile in Nelspruit, White River, Louis Trichardt, Tzaneen and the river valleys of the Crocodile, Olifants and the Letaba. Behind this campaign for the development of the banana industry is the Sub-tropical Research Station at Nelspruit, Transvaal.

Maize

The farmers have adopted improved methods with such enthusiasm in the past five years that the Federation now finds itself compelled to export maize —at a loss.

A surplus has developed with hardly any increase in acreage, but the yield per acre has gone up. Last season's yield of 3 million bags was equivalent to about 17 bags a morgen, or twice the highest national average ever achieved in South Africa. This high yield was the result of conservation farming, the use of double hybrid maize seed, a new technique of planting maize closer and of applying nitrogen fertiliser when the plants are knee-high. This big advance in efficiency has, with the aid of good seasons, created the biggest maize surplus in Rhodesian history.

Parliament had to vote £750,000 to help meet the loss on exporting up to 900,000 bags of maize. Even when this maize sold on the London market at 55*s.* a bag, the Rhodesian Grain Marketing Board had to spend about 20*s.* a bag to get the maize there. It has been estimated that the Board may lose at least 10*s.* a bag.

Sugar

According to the chairman of the South African Sugar Association, sugar production has practically doubled since 1947. Opening the annual congress of the South African Sugar Technologists' Association, he said: ' It was only 10 years ago that the industry received permission to get away from the somewhat rigid quota system in force at the time and expand its operations. Consumption of sugar in South Africa in the past year again increased considerably. There is no reason to suppose that it will not continue to increase.

Citrus

Considerable losses to citrus nurseries and citrus farmers can now be eliminated as a result of two recommendations by the Research Station at Nelspruit.

The first is to spray young trees with systemic insecticides and the second is to dip transplants into plastic solution to prevent the excessive evaporation which results in death to a high percentage of trees. The systemic insecticides are taken up in the sap of the plant and kill insects which feed on the leaves of these plants. These insecticides are ' extremely poisonous to warm-blooded animals and human beings, either when swallowed or inhaled, or when they come into contact with the skin. They are, however, quite safe if used according to the instructions given on the containers '.

It is reported that 6,700,000 cases of citrus fruit were exported in the 1956 season, fetching £13,962,000 gross.

Grapes

Improved varieties of table grapes for the South African and export markets are being developed at the Western Province Fruit Research Station near Stellenbosch. About 1,000 vine seedlings are being tested. About half of these are already in bearing and 12 promising crosses have been selected for further tests. Cross-pollination work was also being undertaken. The object was to produce good early and late varieties and grapes with a better colour and good keeping qualities. Pollen is to be imported for the grape-breeding programme, but several years will have to elapse before any newly developed strains of vines are available to farmers on a big scale.

Copra Quality

At the second meeting of the Copra Quality Sub-Committee of the International Association of Seed Crushers held in Paris recently it was agreed that the relative values of grading schemes could only be assessed by a test period of operation. The members decided to experiment with a suggested analytical grading scheme which they would operate in their mills for a period of six months in order to test its practicability as a means of assessing the relative values of different consignments of copra.

All members were in agreement about the advantages of marketing boards or similar organisations in assuring to the individual producer a fair share of any premium earned for higher quality material.

The Sub-Committee stressed the need for encouraging the replanting of large areas in order to safeguard future supplies of copra and to ensure prosperity for the producing countries whose economy is so closely linked with the coconut palm.

NEW PUBLICATIONS

Growing Field Crops

By G. E. Dungan and W. A. Ross. Pp. 495, illustrated. London: McGraw-Hill Publishing Co. Ltd. 1957. 37*s*.

The avowed object of this book is to present to experienced farmers, city people who plan to move to the country, students of agriculture in high school, Four-H leaders and members, and any person—young or old—a non-technical, easily understood discussion of crop cultivation in the U.S.A. For the achievement of their object the authors describe the processes involved in plant growth, followed by chapters on the development of crops in the field, from selection of the crop to planting, cultivating, weeding, harvesting, storing and marketing, with a final chapter on field-crop records.

Emphasis is laid on care in choosing the crops to grow, selecting the most promising varieties, ensuring that the seed is sound and treating it against pests and diseases. Methods of soil preparation, planting and cultivation are well presented and sound in principle. The authors are undoubtedly right in emphasising the importance of prevention rather than cure in regard to weeds, pests and diseases, but this chapter leaves one with a feeling of its inadequacy. Admittedly, it is patently impossible in a general book to do justice to these important subjects; the difficulty might, perhaps, have been surmounted by referring the reader to books where the matter is treated simply but in greater detail.

Perhaps the most satisfying chapter is that in which breeding and improving crop plants are described. While this is not treated exhaustively, the explanation of the theory and practice of plant breeding is clearly stated and well illustrated, particularly regarding hybridisation of corn.

The subject is treated objectively, is expressed in a readable—almost conversational—style, and many of the numerous illustrations assist the text. Consideration is given to all the major crops grown in the U.S.A., although the cultivators of nearly two million acres of rice in that country will find no mention of this crop. Although the advice given is sound and the technical information conforms with present knowledge of the principles and practice of agriculture, the book falls short, as indeed it must, of the authors' objects. This is undoubtedly because it is impossible to write on such a subject for experienced farmers and at the same time for children. The information is insufficiently comprehensive or detailed to be of great use to experienced farmers. The fact is that the book is written by two experienced teachers of agriculture for the young student. This view is borne out by some rather childish diagrams, the provision of a very lengthy appendix giving common field-crop terms and by a bibliography of motion pictures and filmstrips available to illustrate each chapter.

'Growing Field Crops' is an excellent book for young students and will also give some idea of the difficulties that confront city people who plan to move into the country, but it is difficult to believe that the experienced farmer is so uninformed as to derive much assistance from this book.

D. H. GRIST

Radioisotopes in Biology and Agriculture

By C. L. Comar. Pp. 481. London: McGraw-Hill Publishing Co. Ltd. 1957. 67*s*. 6*d*.

Biologists were among the first to avail themselves of the powerful and versatile tools which came into being with the discovery of radioisotopes, and when the particle accelerators and nuclear piles made these substances cheaper and more accessible, biological research received a fillip of no mean magnitude. In fact, certain problems, such as the mechanism of photosynthesis in plants, once tackled with enthusiasm, and then considered virtually insoluble, were at last amenable to attack when isotopes such as C-14, N-15, P-32 and S-35 were introduced.

Agriculture, being but a form of applied biology, was naturally also to benefit. Many of the biochemical problems so vitally important in biology were also of interest to the tiller of the soil, the plant geneticist and the fertiliser expert. There is no readily discernible boundary between the two subjects and this is a good thing, because this lack of delineation makes it easier for exponents in the two fields to approach each other with their common problems and interests.

To those engaged in either of these two overlapping activities, whether they be workers in the field or at the laboratory bench, radioisotopes must come as a ministering angel, offering them very convenient methods of tackling an endless variety of problems. But these same isotopes, offering as they do certain manipulative difficulties, and even hazards to the uninitiated, are apt to seem rather awesome to those unconversant with their peculiarities. To span the gap comes this very valuable book, most carefully prepared by a former director of a laboratory at the University of Tennessee and now attached to the Oak Ridge Institute of Nuclear Studies. The book gives not only the underlying theory of the action of the radiations, and the measurements involved in their use, but also a very practical treatment of the setting up of isotope facilities and the carrying out of experiments with these isotopes. The volume will be of the greatest value to anyone embarking upon the application of radioisotopes to the fields covered in the text and, indeed, to others engaged in related work.

There is a remarkable freedom from mistakes, but there is certainly an error in reference (9) on p. 171.

The advice given on p. 162 that 'the individual should be aware of the explosive potentialities of perchloric acid before using it' is likely to prove cold comfort to a worker wishing for some hints on how to prevent accidents with this material.

It is nice to see that the author has graciously conceded the point that the so-called 'columbium' is henceforth to be called 'niobium'. Other American writers might note this also, for many of them are reluctant to give up the old name for reasons that are obvious.

If any criticism can be offered, it is that some of the elements listed in the chapter on individual radioisotopes can have virtually no interest to the readers to whom the book is addressed.

A blameless book does not exist, but this volume is excellent in almost every way and deserves great popularity. It will be a very valuable addition to the library of many research institutes throughout the world.

F. R. PAULSEN *

* Dr. F. R. Paulsen is the Editor of *Atomics*—a Leonard Hill publication.

Tobacco Farming in Rhodesia and Nyasaland

This interesting little book written by Dr. F. A. Stinson, Director of the Tobacco Research Board of Rhodesia and Nyasaland, is a record of developments in the tobacco industry in those countries from 1889 to 1956. The organisation of research, administrative progress since 1951, the gradual evolution of technology, the use of land, labour and machinery, fertilisation methods, soils, varieties and 'priming' practices are all reviewed. Although this is a history of developments over more than 60 years, Dr. Stinson is all the time looking ahead to future progress in the industry. Among the items of general information in the brief introduction we learn that we owe the development of the cigarette to a soldier in the Crimean War who lost his pipe.

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Colonial Research in 1955–56

The report for 1955–56 of the Colonial Research Council states that 88 new schemes and 66 supplementary schemes, involving grants totalling £1,889,486, were made during the year, bringing the total sum allotted to Colonial Development and Welfare Research Schemes since 1940 to nearly £15,389,486. About 32% was for agricultural, animal health and forestry schemes, 15.5% for medical research, 12% for fisheries research, 9% for tsetse and trypanosomiasis research, 10% for social science and economic research, 8% for insecticides research, 5% for research sponsored by the Colonial Products Council, 3.5% for anti-locust research, and 5% for miscellaneous schemes, including building and road research. Apportionment by territory was as follows: East African territories 36%, West African territories 19.5%, South-East Asian territories and Hong Kong 10%, West Indian colonies, British Guiana and British Honduras 10.3%, Central African territories (Northern Rhodesia and Nyasaland) 5.6%, other territories and schemes of general interest 18.6%.

Published together with the reports of the Colonial Research Council, Committee for Colonial Agricultural, Animal Health and Forestry Research, Colonial Economic Research Committee, Colonial Fisheries Advisory Committee, Colonial Medical Research Committee, Colonial Pesticides Research Committee, Colonial Products Council, Colonial Road Research Committee, Colonial Social Science Research Council, Tsetse Fly and Trypanosomiasis Committee, Director, Anti-Locust Research Centre and Research Matters not covered by the above Reports of the Specialist Advisory Bodies; by H.M.S.O., price 10*s*.

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Dictionnaire des Huiles Végétales

This valuable work of reference presents in dictionary form information about over 1,000 species of oil-yielding plants. So as to be internationally useful, this information is arranged alphabetically under the botanical name; and for greater ease of reference an index is appended which gives the French common name and as many of the local names as M. Paul-H. Mensier, the author, has been able to assemble. The book is a more detailed version of his earlier work, 'Lexique des Huiles Végétales'. In the greater space available in the present volume the author gives a brief description of each plant, its chief characteristics and those of the oil that can be extracted, together with an analysis of the oil. Where the oil obtained is a by-product (such as cotton), mention is also made of the other products and points of interest. Similarly, where oil is the main product, any interesting by-product is noted.

There is a short glossary of technical terms.

The book is published (in French) by Éditions Paul Lechevalier, 12 rue de Tournon, Paris (VI^{e}), in the Encyclopédie Biologique series, price F. fr. 10,000.

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The Cocoa Industry

Two reports on cocoa growing have recently been produced by Cadbury Bros. Ltd. That on 'The Expansion of the Cocoa Industry in Jamaica' is by D. H. Urquhart, late Director of Agriculture in the Gold Coast, who visited Jamaica last year. Under the cocoa expansion scheme it is proposed to place 50,000 acres under cocoa by 1966–67. Mr. Urquhart, who considers that this target will be reached, has suggested certain variations in the original scheme. Among these is the adoption of the budding method of propagation devised by Mr. B. F. Topper—which was described in the January issue (WORLD CROPS, 1957, 9, 38)—instead of the method of raising rooted cuttings. Price 5*s*.

The other report is on 'Cocoa Growing in the Dominican Republic, Mexico, Guatemala and Costa Rica', by G. A. R. Wood. With the exception of Guatemala, where production is on a very small scale, aspects of cocoa growing covered include climate and soils, pests and diseases, harvesting and preparation, marketing and the future of production.

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EPPO Publications

Report of the Second International Conference on Mediterranean Fruit Fly (*Ceratitis capitata* Wied.).—The report of M. Frezal to the European Productivity Agency of the OEEC is published as an appendix. Compiled from information obtained in the course of visits to the Mediterranean countries, it covers in detail the present state of knowledge and practice in regard to Mediterranean fruit fly in Europe and elsewhere. The conference recommended a programme of co-ordinated research in all the countries affected by the pest. Price 6*s*. or F. fr. 300.

Report of the Fourth International Conference on Fall Webworm (*Hyphantria cunea* Drury).—The whole of Hungary and areas of Austria, Czechoslovakia, Roumania, Yugoslavia and the U.S.S.R. (Ukraine) are at present infested with this pest. Recommended methods of control are outlined in this report, which urges the need to intensify efforts to prevent, or at least to delay, the spreading of the pest into uninfested areas, particularly across national frontiers. It recommends the organised education of all interests concerned so that any outbreak may be speedily detected and dealt with. Price 4*s*. or F. fr. 200.

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East Malling Research Station

The annual report for 1956 contains for the first time the Administrative Report as well as the Research Report.

The Research Report is again divided into four parts, the first giving a short summary of the work on the farm, the second a review of the research programme, the third research

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reports, and the fourth bulletins for fruit growers.

To counter past criticism that many interesting points discussed in Part II are not readily accessible to the practical grower, two popular articles have been included in Part IV summarising the main practical items in Part II.

The full text of the Amos Memorial Lecture on plant physiology by Prof. F. G. Gregory appears in Part III, which also includes a paper reviewing the history of some of the research station land, and papers on rootstocks, propagation, blossom periods, breeding, spray damage, hop *Verticillium* wilt, apple scab, pear sucker, ground beetle damage to strawberries, and the effect of DDT on orchard insects and mites.

The topical subjects discussed in Part IV include apple scab, collar rot, control of bacterial canker of cherry by streptomycin, an economic planting system for strawberries, weedkillers under fruit trees, and predacious spiders and mites on fruit trees.

The report is well illustrated with line drawings and photographs.

Obtainable from the Secretary, East Malling Research Station, near Maidstone, Kent, price 17*s.* 6*d.* (post free in Great Britain) or $2.50.

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Alabama Polytechnic Institute

' Boron Requirements of Crops in Alabama ', Bulletin No. 305, sets out boron deficiency symptoms in various crops, gives sources of boron for fertiliser use, and results of experiments conducted at the Experiment Station. ' Southern Fusiform Rust ', Bulletin No. 304, is the result of a study of the rust, *Cronartium fusiforme*, which attacks pines in the coastal plain area of Alabama.

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Commonwealth Economic Committee

We have received copies of two more commodity reviews for 1956: ' Industrial Fibres ' and ' Vegetable Oils and Oilseeds '.

World production of the chief industrial fibres showed a marked rise in 1955–56 and reached a record level. *There was also a further substantial increase in the world output of vegetable oils and the total tonnage was the highest ever recorded.* Because of a relative decline in the consumption of these oils for soap production and other technical uses, a larger proportion of the total output was available for edible purposes.

' Industrial Fibres ' comprises summaries of production, international trade, consumption, stocks, prices and customs duties for cotton, wool, rayon and other man-made fibres, mohair, silk, flax, jute and jute manufactures, sisal and other hemps, coir and kapok. It covers, in detail, developments up to the close of the 1955–56 season and gives comparisons for earlier post-war seasons as well as for the average of the five immediate pre-war years. In each section particular reference is made to the part played by Commonwealth countries and to their interests, whether as producers or consumers.

All the regular features of earlier editions are brought up to date and much new material added, including special sections describing changes in the position of the U.K., the U.S.A. and Western Europe as markets for Commonwealth fibres.

' Vegetable Oils and Oilseeds ' contains detailed statistical appendices showing, for each of the main consuming countries, the annual supplies of vegetable oils, with production figures for soap, margarine and compound cooking fat and the quantities of the various oils and fats used in the manufacture of these commodities. There is a section on import duties on oils and oilseeds in importing countries and a summary of the world production of and trade in whale oil.

Bookshop Service

All books reviewed in WORLD CROPS *and all other scientific or technical books may be obtained from :*

Technical Books,
308 Euston Road,
London, N.W.1
Telephone: Euston 5911

Prompt attention is given to all orders

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N.I.A.B.

The second supplement to the loose-leaf ' Handbook of Descriptions of Cereal Varieties ' recommended by the National Institute of Agricultural Botany has now been published and includes detailed descriptions of Dominator, Fylgia II and Koga II. These bring the set of descriptions up to date to include all the varieties recommended by the Institute and included in the Cereal Seed Crop Field Approval Scheme. These descriptions are particularly intended for the use of the field inspectors under that Scheme, but are also of value to all concerned in the recognition of cereal varieties.

Obtainable from the Secretary, N.I.A.B., price 1*s.* each, post free, or 10*s.* a dozen. Copies of the original handbook and first supplement are still available at 20*s.* each.

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Other Publications

We have received copies of the following publications:

Agriculture in the British Economy, the full record of the proceedings of a conference, sponsored by Imperial Chemical Industries Ltd., which considered the part which home agriculture could, or should, play in providing the food requirements of Britain (see WORLD CROPS, 1957, **9**, 41). Price 21*s.*

Paddy Rice Production and Potash Fertilisers in Japan and *The Supply of Nutrients to Cotton with special reference to Potash*, published by Verlagsgesellschaft für Ackerbau m.b.H. Both these publications contain useful general information about the use of fertilisers. According to Dr. Remy, the author of the rice booklet, the use of potash in paddy rice production has made remarkable progress in Japan in recent years. Yields obtained are the highest of any Asian country. Dr. Glander, the author of the cotton leaflet, states that potash exercises a beneficial effect on the quality of the lint, increases the resistance of the plant to frost and to pests and diseases and can combat some physiological disorders.

Report of the School of Agriculture, 1956, *University of Nottingham*, which includes articles on ' The Role of Boron in the Nutrition of Certain Legumes ', ' Mycorrhiza in Grasses and Cereals', 'Transplanting of Sugar-beet ', 'A Multi-purpose Crop Drier ' and 'Aphid Movement Within Crops '.

A revised *Agricultural Products Brochure* for the ring binder of *F. W. Berk and Co. Ltd.*, giving information about their complete range of fungicides, insecticides, fertilisers and trace elements, and turf-treatment products.

MACHINERY AND EQUIPMENT

The ' Quicklift ' screw grain conveyor seen in action

For Lifting Grain

The 'Quicklift' screw conveyor is a unit for loading, unloading or moving grain, which can be used either at an angle or horizontally. It will lift wheat vertically at about 2 tons per hour and will convey it horizontally at over 10 tons per hour; when operated at an angle it will deliver at intermediate speeds, depending on the slope.

It is made of 4-in. reinforced steel tubing; the basic unit is 9 ft. long, but this may be extended with an extension piece to 25 ft. if so required. It can be operated by a ½- or 1-h.p. electric motor or petrol engine and is very cheap to run.

The unit can be lifted by one man, as the basic unit weighs only 33 lb., or 68 lb. if the ½-h.p. motor is attached. It is so light and adaptable that it may be used for a number of jobs around the farm. The manufacturers are Opancol Ltd.

For Harvesting Maize

The International Harvester Co. have produced a special attachment which can be fitted to the McCormick harvester-thresher No. 141, and with this added it is possible to gather, snap, shell and clean corn and all in one combined operation. Thus on mixed farms it is possible to use the same harvester-thresher for small grains, beans, legume seed, as well as for maize. The fitting of the special maize unit takes 60 min.

This unit is placed in front of the harvester-thresher so that the operator gets a clear view of the prongs. He can thus raise or lower the hinged gathering points, depending on whether the stalks are standing up straight or are leaning. Thus even under the worst field conditions he can get all the corn and clean the field completely.

The ears are snapped off instead of being squeezed off, and in the husking roll the ears are held firmly between the concave inner surface and the rasping bars so that shelling is thorough and complete. As it emerges from the thresher the corn is really clean and ready for bin drying.

This self-propelled combined machine is steered by the rear wheels, so that the operator can guide it along the rows with precision and so ensure that the maximum harvest is obtained. The weight of the corn in the tank gives added traction to the big driving wheels, which makes it possible for the machine to be operated on wet ground.

A farmer who shells his maize crop in the field in this way instead of in the barn or granary can harvest earlier, as he does not need to wait for the moisture content to be less than 25%. This earlier harvesting reduces a possible loss occasioned by leaning stalks, loose ears, insects or adverse weather.

Reader Service

For further information on any item of machinery or equipment reviewed in this section please write to:

Reader Service,
WORLD CROPS,
Stratford House,
Eden Street, London N.W.1,
England

For Land Clearance

The ' Treehog ' is a portable circular saw which has been specially designed for land clearing work. Its main uses are for tree-felling, cross-cutting, logging and scrub clearing. It can also be used for hedge-cutting, rough grass cutting and for cutting sugar-cane or sisal or kale.

The machine is fitted with a 27-in. Sheffield steel blade which cuts up to 13 in. in depth. Trees and logs of more than 17 in. diameter can be tackled by cutting in at different positions with a sweeping movement of the machine. The circular blade can be fixed in any of 12 different positions by a simple movement of a lever. Thus it can be used to cut horizontally, vertically or at an angle.

The power unit is a 320-c.c. or a 420-c.c. petrol-driven engine and so

The ' Treehog ' portable circular saw has many uses. Here it is seen with the blade set vertically to cut logs from a felled trunk

the cost of fuel is negligible considering the amount of work which can be accomplished in a short period of time. It is operated by one man, so the labour charges, too, are not high.

Bag-Sealing Attachment

The ' Faseal ' portable bag-sealing attachment manufactured by the Thames Sack and Bag Co. Ltd. is a unit which is easy to operate and makes a very neat seal. By means of a crepe strip fitted over the top of a filled multi-wall paper sack, it ensures a perfect closure. The strip will also act as a reinforcement against the weakening effect of the perforations made by stitching machines. The crepe and the stitching cotton are severed simultaneously by means of a small guillotine. The attachment includes a mirror to give the operator an all-round view of the entire sealing operation.

The ' Faseal ' is particularly useful where multi-wall paper sacks are alternated with jute, cotton or other fabric sacks. When the run of paper sacks has ended, the ' Faseal ' can be put out of commission merely by throwing over a spring-loaded hinge; no unscrewing or dismantling is necessary.

Grain Storage Silos

Crittall grain silos are hot-dip galvanised. This means that the steel used in their construction has been dipped in molten zinc at 860°F. This treatment ensures not only a coating of 1½–2 oz. of zinc per sq. ft. of steel, but also an actual amalgamation of the metals. This positive rustproofing can be relied on as a permanent protection against corrosion.

The corrugated sheet panels can be erected singly or in banks. A basic silo has four sides and four corner posts and this can be extended by the addition of more sections and more posts. The standard sections are easy to handle and simple to erect, using unskilled labour, and the size can be varied to meet all farming requirements.

For the construction of large silos, of the size required by grain merchants, flour millers and maltsters, there are panels of heavier gauge and stronger posts to take the weight of 50 ft. of storage. This class of installation is in the form of a complete unit with delivery hoppers and an integral roof.

A Crittal grain silo installation in the U.K.

A large silo, suitable for grain merchants, millers and maltsters, made up of heavy gauge panels and complete with built-in hoppers

All silos can be provided with chutes, drying and suction panels, manholes and hoppering, according to requirements.

Bulk Grain Drying

There are five models of the Blanch-Bettison batch grain drier, designed to deal with large, medium and small harvests, ranging from 100 to 400 tons. They solve the problem of the high and irregular moisture content of grain which has been harvested with a combine-harvester.

The drying unit consists of a holding hopper, an air heater and a drying hopper in which hot-air ducts are fitted to divide the charge of grain into individual sections, each of a thickness equal to a sack of grain. The hot-air inlets are all on one side, the exhausts are on the other. Thus moisture-laden air from the bottom does not have to rise right up through the whole batch to get away. This ensures perfectly even drying.

The heating unit can be either coke- or oil-fired. The oil-fired furnace has a self-proportioning oil burner which once set is foolproof. The unit is installed complete with an electric fan, which can be operated on a single-phase electric supply system. It is safe to leave the drier unattended or operating all night, as the thermostatic control will switch off the flow of oil and the fan should anything go wrong.

Where building height is a problem the holding hopper can be dispensed with and the wet grain can be fed direct from the elevator into the drier. The oil burner uses diesel oil, so that the same storage tank can be used for the refuelling of tractors. The oil feed is by gravity, and the minimum height required for this is 7 ft. above ground level.

According to the makers, the moisture-extraction rate is 3% per ton per hour at approximately 110° F, and 5% at 130–140°F. This means that with a 46-cwt. batch a moisture content of 22% can be reduced to 16% in 4½ hours at 110°F and in 3 hours at the higher temperature. With drier grain the output will be increased. The output is from 12 to 32 tons per day, depending on the model used.

Eliminate the Elements

An important factor in the use of mechanised agricultural equipment is the wear and tear on the operator, which can be serious where there are extremes of climate—torrential rains or even light drizzle, high wind, blizzards and hot sun. There may be occasions when it is essential to operate under severe conditions. With all-weather protection it is possible to work continuously in all weathers. It will protect the driver from chills due to exposure and so prevent lost time, and it will be unnecessary for him to wear cumbersome protective clothing. This gives him maximum freedom so that he can concentrate on the job, which is particularly important when operating in difficult terrain.

The driver also needs protection when he is clearing secondary jungle, thorny scrubland or in high grass or bamboo, or when he is cultivating low

The Blanch-Bettison grain drier. Even drying is ensured by the position of the hot-air ducts

tree crops, such as young coconuts, young rubber or in fruit orchards. At the same time he must have good all-round visibility to avoid accidents and to ensure that the work is carried out exactly as required. In certain circumstances it may be necessary to work right round the clock with relays of drivers.

The 'Sun-Trac' cab will meet these exacting requirements. It provides maximum visibility and has special low windows mounted in the front panels, so that the rear of the front wheels are in constant view; it is rigidly constructed of arc-welded rolled-steel angle section and panelled in welded steel sheet, so that it can withstand the severe buffeting of branches and thorny brushwood, which would otherwise distract the driver or cause him injury. The windows are of toughened Triplex $\frac{3}{16}$-in. safety glass, set in their

There is a 'Sun-Trac' cab for every make of tractor, and for every purpose, with front- or rear-mounted implements

frames with a special self-sealing 'Weatherstrip'. Sponge rubber is used for sealing the joints with the fuel tank and the bonnet. The cab is painted with three coats and the interior is sprayed with an anti-drumming compound. A high roof light for night work can be fitted as an extra. There is a 'Sun-Trac' cab to fit every make of tractor, whether on wheels or caterpillars.

Prefabricated Silos

Conder silos are constructed from compact prefabricated steel panels. This enables silos of almost any size to be constructed from simple standard components, easily packed, handled and assembled. There are Conder installations ranging in size from banks of bins each holding 350 tons, and nests of 1,500 tons made up of bins of 150 tons capacity, to single-bin units of 25 tons or less, all built with the same standard components and varying only in gauge of plate according to the size and height of the installation.

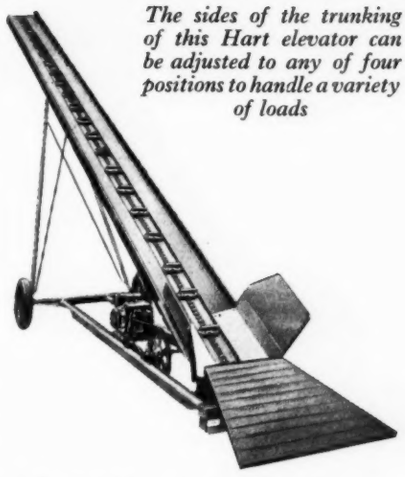
A remarkable feature is the integral conveyor tunnel which can be built into a nest of bins as part of the central division, while still giving the maximum storage capacity for a given floor area. This serves the dual purpose of housing the bottom conveyor system at or above ground level, as conditions dictate, and of providing a main air duct where ventilating and conditioning are required.

The bin components are finished with a special application of rubberised paint stoved to 360°F to provide a lasting bond of paint and metal, able to withstand rigorous weather conditions and thus making Conder installations suitable for outside erection with their own integral roof. Roof structure components are made for bolting together so that they can be knocked down flat for shipment overseas.

Other features are the patented method of strengthening the panel junctions with U-shaped cleats and the application of self-emptying floors and perforated metal floors for drying and conditioning units.

A Four-purpose Elevator

An elevator, which can handle sacks, bales, boxes, roots and loose grain, will meet all the requirements of agriculture; the Hart elevator is, in fact, four elevators in one, because the sides



The sides of the trunking of this Hart elevator can be adjusted to any of four positions to handle a variety of loads

of the trunking can be adjusted to any of four different positions to handle a wide variety of loads.

The trunking in its widest position provides a broad, flat channel for sacks, for baled hay and straw, for large cartons and for fruit boxes. If the trunking is closed to the first or second position, according to the type of root crop, it can be used for elevating ears of corn, sugar-beet, potatoes and other large and small root crops, either for bulk storage or for transport. For the rapid elevation of loose grain and chopped fodder the trunking is closed on to the pusher plates and by reversing the direction of movement of the conveyor belt the machine can also be used for the discharge of grain to a lower level.

A 680-ton Conder installation for storing grain. The bins, which are arranged in banks, are made of standard components

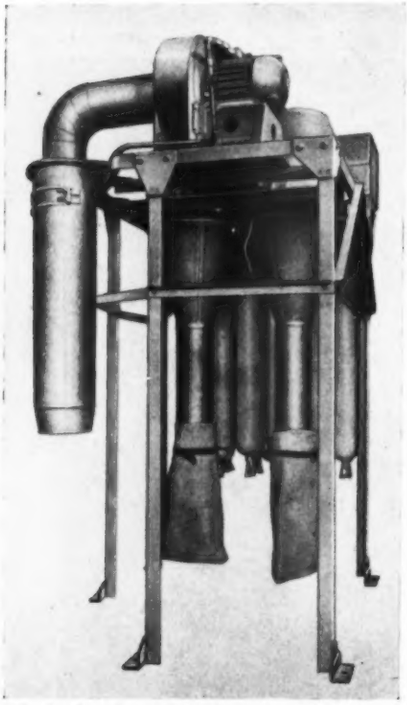
The motive power is provided by a petrol engine, or an electric motor can be fitted, if required. The machine can be operated at a slow speed to give ample time for off-loading sacks, bales or cartons, or fast to ensure the speedy clearance of the hopper, when dealing with small loose materials, such as grain. The elevator is adjustable for height and angle by means of a hand winch and cable fitted with a fool-proof ratchet. The long-reach model is adjustable from 8 ft. to 18 ft.; the junior model from 7 ft. to 14 ft. in height. Both models are easily manoeuvrable by one man and a built-in hitch is provided, so that the Hart elevator may be attached to a tractor or to the tow-bar of a lorry.

For Cleaning Sacks

A self-contained unit for cleaning all sizes of hessian and cotton bags is now offered by W. S. Barron and Son Ltd.

The cleaning plant is of all-metal construction, is designed for heavy and continuous use, and it requires the minimum of attention and maintenance.

The sacks are held under the cleaning nozzle and are then pulled away. This is repeated to ensure that both sides of the bag are thoroughly cleaned. If very high outputs are required, three operators can be arranged around the nozzle and the bags can then be cleaned just as quickly as they can be applied to the nozzle.



Sack-cleaning plant. The cleaning nozzle is seen on the left

The cleaning action is searching yet gentle and does not involve beating or any other scouring action to cause any wear on the sack, yet it produces clean, bright sacks at the rate of over 300 per hour. All dust and residue in the sacks is extracted and collected and not infrequently the material recovered pays for the cost of the installation.

No additional equipment is required, as the motor, air collectors and air filter bags are all included. The filter bags ensure that no dust escapes into the surrounding atmosphere.

Grain Conveyors and Elevators

Agricultural Supplies (Cambridge) Ltd. are the manufacturers of the 'Simplex' grain conveyor and the 'Simplex' grain elevators. The former is of the chain and flight type with robust timber troughing, made in easy-to-assemble lengths. Grain or any granular free-flowing material is moved silently along the trough by means of a malleable chain with 5-in. flights cast into links, which run on cast-iron sprockets. These sprockets are keyed to steel shafts running on ball-bearings. The drive is from a 1/1½-h.p. geared electric motor, mounted on a slide.

The elevator is of all-steel construction and is built up in easy-to-erect standard sections, each 4 ft. in length, with a special length to complete the elevator to the height required. The grain is lifted in 6-in. pressed-steel buckets, carried on a three-ply rubber belt fitted with a turnbuckle tensioning device. An inspection window is fitted into one section of the trunking.

'Hi-Level' Elevator

The new Markham 'Hi-Level' elevator attracted considerable interest when it was shown at the 1956 Smithfield Show for the first time. It has been designed for the economic handling of sacks, bales, sheaves, beet, crates etc., and has an impressive range of loading and delivery heights. It can also be used as a horizontal conveyor. The loading and delivery levels can be speedily adjusted; the elevator bed is held in position by means of twin hydraulic rams operated by a single quick-acting hand pump and a two-way control valve. Construction is robust and the modern design of the pressed-steel elevator bed enables it to be easily cleaned.

The loading height of the 'Hi-Level' elevator is adjustable from ground level to 7 ft. 6 in.; the delivery height from 4 ft. 6 in. to 19 ft.

The loading height is adjustable from ground level to 7 ft. 6 in.; the delivery height from 4 ft. 6 in. to 19 ft. As a horizontal conveyor it can be used at any height between 4 ft. 6 in. and 7 ft. 6 in. It is powered by a 2-h.p. air-cooled Villiers or B.S.A. engine and the conveyor speed is between 75 and 80 ft./min.

For purposes of storing agricultural products it will be appreciated by market gardeners, farmers and planters that four or five times as much material can be arranged to occupy the same ground space in barns and storehouses when bags or crates are scientifically stacked and the expensive, exhausting and time-consuming labour of lifting manually is avoided. The saving in capital investment on buildings and in handling costs will more than offset the first cost of the machine.

A New Villiers Engine

First introduced at the Smithfield Show, the new Villiers Mark 7F two-stroke engine is now in production. Of 98 c.c. capacity, the 7F is a vertical-shaft engine, which has been designed specially to power rotary grass cutters. The machine is extremely compact, the engine is blower-cooled, the cowling being extended to envelop both the fan and the fuel tank. Another

interesting feature is the provision of a recoil-type starter which is bolted on to the top of the engine, but the ordinary rope and pulley starting can be fitted, if required. It has a governor-controlled carburettor with an easy-to-clean oil-wetted filter. This engine develops 1.25 b.h.p. at 3,000 r.p.m. and 1.4 b.h.p. at 3,500 r.p.m.

Villiers engines already provide the motive power for the Clifford range of rotary cultivators; the Markham ' Hi-level ' elevator; the Bonser light truck, which is used on farms, market gardens and smallholdings; the Kaye motorised sports ground roller; the Phillips ' Whirlwind ' range of rotary grass and bramble cutters; the En-Tout-Cas 6-cwt. motorised sports ground roller; the Stothert and Pitt vibrating trench roller; the Landmaster ' Kestrel ' cultivator or snow plough; the Hayter 24-in. motor scythe and the 26-in. rotary grass cutter; the Teles chain saw for cutting heavy timber; the Mayfield motor scythe and the Mayfield ' Weazel ', a small tractor for operating in snow; the ' Midget ' hoist of A.C.E. Machinery Ltd. and the roof-rig of the British Hoist and Crane Co.; the Allen motor scythe with an array of attachments; the Barford power scythe and the ' Atom-15 ' multi-purpose tractor; the Wrigley truck with an overall width of only 3 ft. 4 in., enabling it to traverse narrow lanes and tracks; the 20-in. master-mower of Thomas Green and Son Ltd.; the Allman portable sprayer and fire-fighter; the Hydrovane mobile air compressors for spraying paint, limewash, insecticides, creosote and dis infectants; the Munro hayloader and a trolley-mounted post-hole borer offered by Graziers' Buying Service, both products of Australia.

The new Villiers Mark 7F two-stroke engine, designed specifically to power rotary grass cutters

Portable silos constructed with Sisalkraft

Altogether nearly 40 different manufacturers exhibited machinery and equipment powered by Villiers engines at Smithfield Show, held at Earls Court in London last year. The applications included tractor-cultivators, milking machines, elevators and stackers, sprayers and dusters, motor mowers and rotary grass cutters, high-pressure washing plant, fire-fighting equipment, sorting and winnowing machines, pumping sets, chain saws, winches etc.

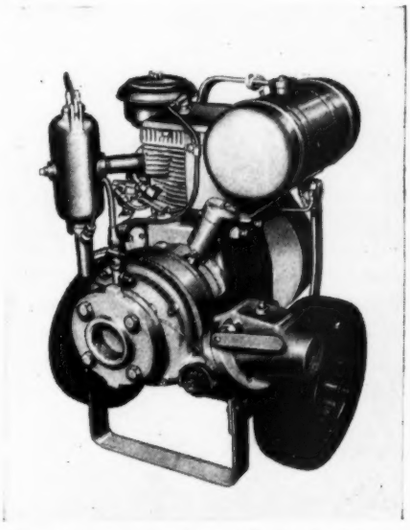
Sisal on the Farm

The main uses of ' Sisalkraft ' in agriculture are (1) for lining potato and root clamps, (2) in the construction of portable silos, and (3) for covering hay stacks. ' Sisalkraft ' is a material of interwoven sisal fibre, so reinforced as to be virtually untearable.

When used for lining clamps, the ' Sisalkraft ' method is said to require very much less soil for earthing up and for the covering layer the cheaper small straw can be used. If straw is in abundant supply, the use of earth may even be dispensed with altogether and two layers of ' Sisalkraft ' used instead, with a layer of straw underneath and on top of each layer of ' Sisalkraft '. Inspection of a clamp can easily be effected by removing a portion of the covering layer of earth and straw and making a vertical cut in the ' Sisalkraft '. After inspection, the two flaps should be brought together again, sufficient straw stuffed underneath the cut to make a slight ridge so as to prevent the edges drooping inwards and permitting the entry of moisture, and a good-sized patch of new ' Sisalkraft ' applied. The top layers of straw and earth should then be replaced.

Silage is invaluable to any farmer who has to feed a large herd of cattle during the winter. Many farms have an abundance of ' back-end ' grass which is wasted unless used in this way; silage is not liable to spontaneous combustion, cannot be fired and is frostproof in the bulk. There are two sizes of these portable silos: No. 1 has a diameter of 10 ft. and a capacity of up to 18 tons; No. 2 has a diameter of 15 ft. 6 in. and a capacity of up to 45 tons. In each case welded steel fencing is supplied, which may be re-used for several seasons; it is only necessary to replace the ' Sisalkraft ' lining each year.

For covering haystacks, coir stack nets are supplied to hold the ' Sisalkraft ' in place, and these are held down by weights.



The wheel mounted model of the Myers irrigation pump

Pumps for Irrigation

Myers ' Pressure Rain ' irrigation pumps are offered in 30 combinations based on five pump sizes and seven engine sizes.

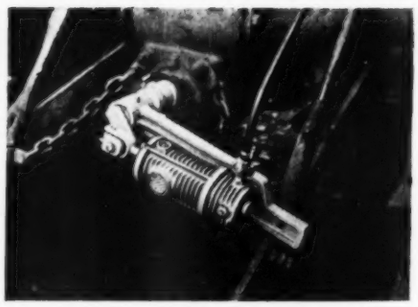
The output ranges from 100 to 1,800 gal./min. and the working pressures from 60 to 200 lb., when working at 80% of full throttle.

These centrifugal irrigation pumps are equipped with automatic cut-off switches which stop the engine if pumping pressure falls below a predetermined minimum and with high-temperature cut-off switches to prevent overheating.

There is a choice of skid or wheel mountings and wheel packages are available for skid-mounted units.

A Tractor Air Pump

The Edwards air pump is a useful accessory to carry on a tractor. It can be coupled to the p.t.-o. shaft in 60 sec. and will inflate its four tyres from flat to working pressure in under 6 min. The pressurised air can also be used to operate a spray gun or to charge the pressure bottle of a spraying lance, so that its applications include spray-painting, disinfecting, creosoting, limewashing, mist-oiling and anti-malarial spraying.



Close-up view of Edwards air pump fitted to the p.t.-o. shaft of a tractor

For Drying Grain

The grain-drying plants of Messrs. Penney and Porter Ltd. have capacities ranging from 10 cwt. to 10 tons per hour (10,160 k.p.h.). In particular, the Mark 1 ' Major ' grain drier has aroused considerable interest in European countries, where small farms predominate.

This drier is not only small, but very compact and can be easily installed. It has a capacity of 10 cwt. per hour, when dealing with milling wheat at 150°F. (65°C.), and when reducing the moisture content from 21% to 16%. The firing equipment is thermostatically controlled and, after setting the thermostat at the required temperature, the burner can be ignited and left running for days or even weeks on end, so long as the supply of fuel is maintained. The fuel used is ordinary diesel oil, so that no additional storage tank will be required, as the drier and the farm tractors can both draw on the same supply.

This firm are also manufacturers of rotary adjustable grain screens for fitting to combine-harvesters. Regular shipments are being made to various parts of the world and a quantity of these screens has even been sent by air to Baghdad to be fitted to the Oliver 35 combine.

Grain pre-cleaner, showing the screens and the duct for the blowings

For Cleaning Grain

The combine-harvester has necessitated the use of cleaners for the removal of foreign matter in grain. In the pre-cleaner, manufactured by Perry of Oakley Ltd., the grain is fed into the machine through a variable flap which distributes it over the full width of the aeration chamber, where it is subjected to an upward current of air. This carries away any dust, small green matter, light heads and fragments of straw *via* ducting to a collecting bin. The grain then passes out of the aeration chamber to an adjustable slope-grading screen to remove complete heads and larger foreign matter which are collected and carried away by suction. The grain passes through this large screen and on to a finer screen to remove any small seeds. The cleaned grain finally leaves the cleaner via a chute.

The unit has variable air volume control to suit all grain conditions and the blower blade gives air of high velocity and is designed to prevent the fouling of the screens.

For Moving Grain

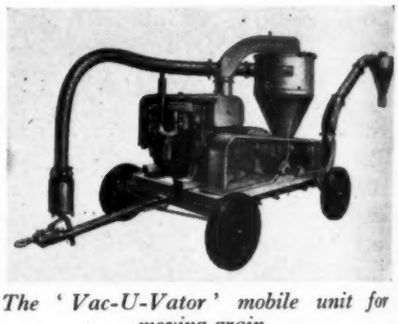
The ' Vac-U-Vator ' is a completely mobile unit for moving grain and similar free-flowing granular materials into and out of silos, barges, rail wagons or lorries. It can elevate grain to a height of 70 ft. or convey it a distance of 250 ft. Its capacity with the standard equipment provided is as follows:

Material	*Bushels/hour*
Maize, oats and barley	1,300 to 1,600
Soya-beans and wheat	800 to 1,200
Rice	1,000 to 1,400

The machine is supplied with either a diesel engine or an electric motor, but the former gives greater flexibility of operation. It is a standard diesel power pack unit, rated at 62.5 b.h.p. at 2,000 r.p.m., at which speed fuel consumption is about 2½ to 3½ gal. per hour.

A 3-stage high-pressure centrifugal fan, operating at speeds of up to 4,000 r.p.m., delivers air at 1,200 to 3,000 cu. ft./min. The grain is separated from the air in a heavy-duty cyclone, which allows the grain to pass down into an airlock, which delivers it into the outlet pipe.

The machine is supplied with a set of rigid and flexible 8-in. pipes in convenient lengths and fitted with ' Snapeze ' quick-release clamps. The suction nozzle has an adjustable outer sleeve and is designed for deep work. A boom with ropes and blocks is provided to assist in handling the nozzle and intake pipe.



The ' Vac-U-Vator ' mobile unit for moving grain

Crop-spraying Attachment

Evers and Wall Ltd. announce the arrival of a new crop-spraying attachment for use on their Clifford Mark I cultivator, to which it is easily fitted by means of studs on either side of the rear p.t.-o. A hinged fixing strap is attached over the steering column. Its tank capacity is 14 gal., and the spray is delivered by an Evers and Wall gunmetal stainless steel pump. The ground crop booms have a 7-ft. 6-in. spray width and are adjustable to heights up to 36 in. The spraying attachment is fitted with a positive non-drip valve for greater economy, as well as for the prevention of damage to turves and lawns when using powerful hormone weedkillers. It may be used on seedlings, bushes and small trees and in every case full coverage is ensured. The tongs may be set horizontally to form vertical booms for spraying raspberries, tomatoes and other soft fruit crops.

Agricultural Chemicals

Fighting forest fires: treatments for silage: plant nutrients: insecticides: herbicide and fungicide

Lawn Fertiliser

Good summer turf growth requires a slow but steady supply of nitrogen as well as adequate moisture.

Fertilisers containing urea formaldehyde products in addition to quickly available nitrogen can provide the necessary nitrogen in useful amounts without repetitive applications throughout the growing season because urea formaldehydes (which, of course, contain nitrogen) are known to disintegrate slowly in soil.

A number of experimental compositions, designed to be used as one-application fertilisers for lawns, have been studied at the Battelle Institute. All applications were made only once, in the spring.

On the basis of total weight of grass clippings obtained during the summer, fertilisers containing urea formaldehyde with an activity index of water-insoluble nitrogen of 57.3 were concluded to provide the most adequate turf growth. They also produced a greater weight of clippings than either activated sewage sludge or any of the conventional fertiliser compositions of equivalent nitrogen content.

*

A New Seed Dressing

Plant Protection Ltd. announce a new dressing to make seed safe against the attacks of pests during storage and of seed- and soil-borne diseases when it has been sown.

'Mergamma' S gives double protection with one seed dressing at a rate of 4–5½ oz. per cwt. (200–300 gm./100 kg.) for cereals (wheat, oats, barley, rye, sorghum, rice and maize) and 12 oz. per cwt. (750 gm./100 kg.) for sugar-beet. It costs less than the separate application of two dressings and protects the seed against pests and moulds while in store and against disease after sowing. In fact, good seed stored in dry conditions will remain immune from insect attacks for a full twelve months from one seed time to the next.

'Mergamma' S can be applied by any method which gives complete coverage of the seed, but the usual precautions in handling mercurial seed dressings should be observed. For the protection of seed against wireworm attack after sowing, a higher concentration of gamma BHC is needed and for this, 'Mergamma' A is recommended.

*

Aerial Spraying of Fertilisers

A new fertiliser has just been sprayed from the air for the first time in Scotland. The fertiliser used was 'Nitra-Shell,' which has a 20.5% nitrogen content, which makes it particularly suitable for aerial application. The even granules are dust-free and so do not get blown away in the process, nor do they adhere to the surface of the leaf, thus eliminating the chance of scorching. The fertiliser can be sprayed aerially late in the season, avoiding the flattening which takes place when a tractor is used.

The trials were carried out with a 'Tiger Moth' plane, which can cover 20 acres an hour at the rate of 2 cwt. per acre, as against 1½ acres per hour by tractor. The plane flies at a height of about 35 ft. and in these trials a few tarpaulins were laid out which confirmed that the granules had fallen evenly over the surface of the ground. The plane equipment was modelled on the pattern used in New Zealand, where aerial dressing of hill land has led to a trebling of productivity.

*

A Store Fumigant

Methyl bromide is well known as a versatile and effective fumigant. In recent years it has been discovered that ethylene dibromide is also an extremely effective fumigant; for some purposes actually more so than methyl bromide.

The various common storage insects show different degrees of susceptibility to fumigants, some being more susceptible to methyl bromide and others to ethylene dibromide. This fact was used in the development of 'Bromotox'.

Field trials over the past few years have shown spectacular results under difficult fumigation conditions as compared to methyl bromide alone. Test insects buried deeply in multi-wall bags of flour indicated excellent penetration. Diffusion throughout the warehouse is rapid and aeration following fumigation is quickly accomplished.

'Bromotox', being a synergistic mixture, is capable of giving effective results at dosages below those required for either methyl bromide or ethylene dibromide alone. Practical field trials have shown effective results in large buildings at a rate as low as ½ lb. to 1,000 cu. ft. of space. It is suggested conservatively that a dosage of 'Bromotox' be used which is 25% below the methyl bromide dosage that is known to be effective under similar circumstances.

For the control of stored products insects in warehouses and old buildings of good construction adapted to effective methyl bromide fumigation a dosage of ¾ lb. to 1,000 cu. ft. of space at a temperature of 60°F or above for an exposure of 18 to 24 hours is recommended.

For atmospheric vault or polyethylene tarpaulin fumigation of such products as dried fruit, cereal products, spices, cheese etc. at 60°F or above, the following schedule of dosages per 1,000 cu. ft. is suggested: 2¼ lb. for 4-hour exposure; 1½ lb. for 8-hour exposure; ¾ lb. for 12-hour exposure.

*

Cheaper Silage

If present growing conditions continue, 1957, unlike 1956, will be a most favourable year for silage making. 'Silotex', an agricultural grade sodium metabisulphite, will provide the farmer with a cheap and simple method of conserving his forage crop.

*

Fire Fighting

'Firebrake' — a sodium calcium borate preparation—was developed by the U.S. Borax and Chemical Corporation, working with the U.S. Forest Services, and was first used on a large scale against a series of major forest fires in California last summer.

The compound, which is supplied dry in 50-lb. sacks and is then mixed with water, can be used either by ground teams or from the air. During

the Californian outbreaks, small 'planes carrying 120 gal. of 'Firebrake', bombed danger spots and held fires in check until the ground crews arrived. On the ground, power hoses can spray 4½–7 gal. of 'Firebrake' a minute—enough to treat 150 sq. ft.

Because it is easy to transport, the compound is especially useful for use in difficult regions—thickly wooded and mountainous areas. It can also be used as a fire resister. Danger spots can be sprayed with 'Firebrake' before fires start and it acts as an effective fire guard. The compound can also be used for reducing the likelihood of fires rekindling (a major danger for fire-fighters) and for strengthening existing fire breaks.

*

For Potato Blight

Spraying with a copper fungicide is the surest protection against the ravages of potato blight. Copper spraying prolongs the growth of the haulm for several weeks, which can mean a valuable increase in yield. As much as 2–3 tons extra potatoes per acre have been obtained from crops treated in this way.

'P.P.' copper oxychloride is a modern fungicide giving excellent protection against potato blight. It is easy to handle and mixes readily with water and may be applied through high- or low-volume sprayers.

For the best results this fungicide should be applied before blight usually appears. Warm, damp weather usually precedes an attack of blight. Further applications should be made at intervals of 2–3 weeks. For successful low-volume application it is essential to spray before the haulm has closed over the rows.

*

A New 'Palfsack' for 'Nitra-Shell'

A new type of multi-wall paper sack has been designed by William Palfrey Ltd., manufacturers of 'Palfsacks'. The new 'Palfsack' is a five-ply paper sack, including one-ply polyethylene lined and one-ply bitumen lined. This has been produced specially for the carriage of a new product—'Nitra-Shell'—a granular nitrogenous fertiliser, the advent of which marks the entry of the Shell Chemical Co. into the production of fertilisers.

A form of packaging was required which would enable the product to be transported cheaply and without damage. In order to ensure that the fertiliser will retain its condition and not deteriorate, it must not be allowed to cake owing to damp conditions during transport and storage.

This new type of 'Palfsack' should be of great interest to the chemical industry, especially for agricultural products requiring careful protection against climatic conditions or possible chemical reactions.

*

Improved Silage

A silage preservative containing formic acid, 'Prosil' stimulates the development of lactic fermentation in ensiled forage and interferes with butyric acid and other unfavourable types of fermentations. The result is a well-preserved pleasant-smelling silage of high feeding value, which is very palatable and has a beneficial effect upon the digestive organs of farm animals.

It is used diluted in water (5 litres of 'Prosil' in 100 litres of water) for ensiling corn, sorghums, alfalfa, clovers, grasses, beet pulps and leaves etc. For treating 100 kg. of material 2 to 4 litres of solution are necessary.

Lalang* and Grass Eradication

An experiment designed to study the comparative efficiency of 'Dowpon' on slashed and unslashed lalang, carried out by the Rubber Research Institute of Malaya, showed beyond doubt that the weedicide was much less effective when applied to slashed lalang. Four months after spraying, slashed lalang plots which had received 'Dowpon' at the rate of 40 lb./acre were showing regeneration of about 5–10% of the sprayed plants, whereas in the unslashed lalang plots 10 lb. of 'Dowpon' per acre was sufficient to provide the same degree of control. It is, therefore, much more feasible and economic to spray standing lalang rather than to incur the heavier expense not only of slashing but of the larger amounts of 'Dowpon' required for successful control.

'Dowpon' can be regarded as much the most efficient lalang and grass eradicant available for use in rubber plantations. It is to be noted that considerable caution is required when applying it near young rubber trees.

* Lalang: *Imperata cylindrica*, otherwise known as illuk (Ceylon) or cogon (Philippines)

Reader Service

For further information on any item reviewed in this section please write to:

Reader Service
WORLD CROPS,
Stratford House,
Eden Street, London N.W.1,
England

*

Molybdenised Superphosphates

Substantial response by subterranean clover to phosphorus, sulphur and molybdenum has been obtained in pot trials of sandstone soil from the Running Stream area of New South Wales, Australia. Prior to these tests landowners had difficulty in establishing improved pastures. Nodulation and fertiliser problems were suspected. In the experiments seeds of subterranean clover were inoculated with rhizobia and treated with combinations of molybdenum, sulphur and phosphorus. Response was apparent and maximum growth was directly dependent on the presence of all four factors. As a result of this work it is recommended that molybdenised superphosphate be used at the initial sowing.

*

A Potato Haulm Destroyer

'Hawmac' destroys potato haulm within 10–14 days of application, making mechanical harvesting considerably easier and preventing blight from spreading to the tubers at lifting time. At the same time it will give an excellent control of most weeds. It may also be used at the required stage to check the growth of potatoes for seed.

'Hawmac' may be applied efficiently by low- or high-volume sprayers. It is essential that the sprayer bar is set high enough to obtain complete coverage of the crop. If possible, spraying should be carried out in warm sunny weather, when there is no risk of wind carrying 'Hawmac' on to neighbouring crops.

WORLD CROP REPORTS

INTERNATIONAL

Outlook for wheat

Plantings of winter wheat in *Western Europe* are about equal to those of a year ago and total acreage for harvest is expected to exceed the low level of 47 million acres of last year by approximately 10% if present indications of spring plantings materialise. This would place total acreage near the high level of 1955 and, assuming normal growing conditions, above-average production prospects are indicated.

Last season's production of 1,211 thousand bushels for the area, which was the smallest crop since 1951, was due mainly to the extensive loss in February 1956. 1955 production was 1,389 thousand bushels and the past five-year average is 1,294 thousand bushels. In addition to reduced quantity, the quality of the 1956 crop was poor. There has not been much loss from frosts this season and recent weather conditions have been reported as generally favourable. Crop prospects so far are very promising for most sections of Europe.

Spain is the only major producing country of the area where the prospects for the wheat crop are less favourable than last year. This is attributed to the prolonged drought during the autumn and early winter. Rains during January and February, however, have greatly improved prospects for winter wheat and a fair crop may still be harvested if favourable weather conditions continue. Current official estimates, however, estimate this year's Spanish wheat crop as considerably below normal.

Plantings of spring wheat in France are again expected to be high in spite of appeals by the Government that farmers should plant larger acreages with barley. France's total wheat acreage for harvest will thus materially exceed last year's and a surplus of wheat is expected, if normal weather conditions continue. In anticipation of a large wheat harvest, France may well reduce her imports towards the end of this year to conserve foreign currency and enter the new year with minimum carry-over stocks. Reduced imports may also be expected in some of the other importing countries, though not to as great an extent as in the case of France.

Exports of wheat to Europe by the 'Big Four' (U.S.A., Canada, Australia and Argentina) for the first seven months (July 1956–January 1957) of this crop year have already exceeded 330 million bushels, compared with an annual average (12 months) for the past five years of 426 million bushels. Up to February U.S. exports of wheat to this area had already exceeded total exports for the entire 1955–56 year and are expected to continue at a high rate, with a possible tapering off near the end of the year in view of production prospects outlined above. Canadian and Australian exports to Western Europe, July–January, are running well ahead of the first seven months of last year. Argentina is the only one of the 'Big Four' with reduced exports to Western Europe from a year ago. This is due, however, to Argentina's small exportable surplus from the 1955 crop and her exports should pick up substantially with the recent above-average harvest.

In view of the much improved supply position in Argentina, the outlook for an above-average crop in Western Europe, and the possible return of France to the export market, it seems likely that Europe will not provide as large a market for wheat from the U.S.A., Canada and Australia in 1957–58 as this year. Western Europe, in recent years, has accounted for about 55% of the total world trade in wheat.

SPAIN AND PORTUGAL

The severe damage caused by the February 1956 frosts to olive trees in the European Mediterranean countries was reported last month. Now comes news of a good recovery both in Spain and Portugal.

The 1956 table olive pack in Spain is estimated at 36,500 short tons. Though well below the five-year average of 47,300 tons for 1949–53, this estimate is 50% larger than the short 1955 crop of 24,300 tons.

The 1956 harvest was adversely affected by the February 1956 frosts, which caused much tree damage. In addition, the 'almendrilla' ('little almond') disease caused premature dropping of the fruit in some areas.

Fruit harvested in 1956 was, however, of exceptionally fine quality. There was practically no olive fly damage reported, in contrast to 1955's heavy fly damage that resulted in poor quality olives. Spanish trade officials, therefore, forecast that 90% of the 1956 crop will meet export standards.

Rains in January and February 1957 throughout olive-producing areas broke the drought which began in September. Trees have recovered from the 1956 frosts and a normal crop is possible in 1957.

In an effort by the Government to create a new permanent source of edible oil other than olive oil, instructions have been issued to farmers to cultivate soya-beans and groundnuts in irrigated areas suitable for these crops. Under the order farmers will be given seed and fertiliser on a loan basis, provided they sell their crops back to the Government.

Portugal's production of olive oil from the 1956–57 crop of olives is expected to reach 100,000 short tons. It is nearly 30% above the average for the last 10 years.

In view of the improved crop outlook, the Government now no longer require the blending of olive oil with equal quantities of groundnut oil for local consumption, which has been compulsory for the last year.

LIBYA

Owing to unfavourable weather in most parts of the country, except for western Tripolitania, agricultural production was again below average in 1956 in the majority of sectors. The yield from barley—the principal staple crop—in Tripolitania was estimated to amount to about 73,000 metric tons, but some qualified observers consider this estimate to be too high. On the other hand, it was a comparatively good year for wheat, the harvest having yielded about 16,000 tons in this province, as against about 10,000 tons in 1955. Yields in Cyrenaica of both barley and wheat were even poorer. There were indications in the latter part of the year that serious shortage would occur in many areas and U.S. relief wheat was distributed. Production of most other produce, *e.g.* olives, citrus and dates, was also reported to be below average. However, the production of groundnuts was, quantitatively, very satisfactory and it was

expected that exports in the 1956–57 season might be as much as 50% above the quantities sold abroad in 1955–56. The potato crop was also reported to be better than in the previous year, owing to less blight and no frost.

The production of esparto grass, which in previous years provided Libya's largest or second largest export commodity by value, was probably only about equal to two-thirds of that in 1955. This reduction was, apparently, due not to a diminished supply, but to a curtailment of purchases by the Esparto Corporation while price negotiations with overseas buyers were being conducted. Nevertheless, fears were felt in 1956 that the esparto reserves were being depleted by imprudent conservation and methods of harvesting. For this reason a Libyan delegation went to Spain during the course of the year to study experiments in controlled planting of esparto. It is, however, uncertain whether the results of these experiments can be satisfactorily applied in Libya owing to differences of soil and climate.

COLOMBIA

The possibility is being studied of growing groundnuts in large quantities in the banana area of the Magdalena Department in north-eastern Colombia. The first plantations will be started in mid-1957 and it is hoped that these plantations will make it possible to develop an oil and fat industry in the area.

UNION OF SOUTH AFRICA

Farmers in the Union of South Africa have been growing *castor beans* for a number of years on a relatively small scale, but production is expected to increase sharply during the next few years. In the major producing area of Potgietersrust, North Transvaal, the area planted to castor beans in 1956 is reported to be about 18,000 acres more than in 1955. In 1954 about 4,200 short tons of castor beans were harvested from 7,000 acres. The expanded acreage was planted almost entirely from 100 tons of hybrid seed imported from the U.S.A. Arrangements are being made to bring American plant breeders to the Union to develop adapted hybrids. Beans are planted during October–January and are ready for harvest during March–June. The bulk of the beans is expected to be exported.

SCOTLAND

Average Yield of Farm Crops

	Average, 1946–55	1955	1956
		Cwt per acre	
Wheat	23.5	27.1	27.3
Barley	22.5	27.4	27.2
Oats	17.3	19.3	19.9
Rye	11.4	13.9	16.4
		Tons per acre	
Potatoes	7.5	7.1	8.5
Turnips and swedes	17.2	15.9	18.6

DOMINICAN REPUBLIC

Coffee.—Lack of rainfall in the north of the Republic in the beginning of the quarter had an adverse effect on this crop and yield is expected to be well below average, although quality remains high. Later heavy rainfall retarded ripening and deliveries were reported to be slow.

Cocoa.—The winter harvest commences in November and usually runs to March. Due to good growing conditions it was expected that the crop would be larger than average and may merge with the succeeding crop without interruption. It is expected that the harvest will be absorbed by the national chocolate-processing industry.

Tobacco.—Rain at the end of 1956 helped transplanting operations and a good crop was expected this spring if weather conditions remained favourable. In view of Government interest in improved quality and larger production, the prospects for tobacco are good.

Beans.—There was a widespread shortage of beans last October due to the poor harvest caused by adverse weather conditions and the fact that smallholders have turned over to the higher-paying corn crop. Immediate steps were taken by the Government to import emergency supplies which were distributed at cost through relief centres. The Sugar Defence Commission was authorised to import beans and to arrange for their planting on sugar estates between the rows of sugar-cane, as beans are the basis of the staple diet of the people.

[Acknowledgment is made to *For. Crops & Markets* and to *Spec. Reg. Inform. Services* for much of the information contained in the above reports.]

ENGLAND AND WALES

Agricultural conditions in England and Wales on 1 May, 1957, have been summarised by the Ministry of Agriculture, Fisheries and Food.

Good progress was made with cultivations and sowing on light land, but seed beds on heavy soils were difficult to prepare. Cereal and pulse crops are generally satisfactory, although spring sowings on heavy land were slow to germinate. Some frost damage to early potatoes is reported. Pastures made slow growth and need rain.

Weather conditions

The weather during April was very dry with frequent cold winds and widespread night frosts. Rainfall was well below normal in all parts of the country. Sunshine totals were variable, but were above average in some south-eastern and western districts; average temperatures were about normal in most areas.

Spring sowing

Good progress was made with the sowing of spring corn on light land, where, in general, fairly good seed beds were obtained, but seed beds on heavier soils were exceptionally difficult to prepare and in some areas sowing had not been completed at the end of the month.

Roots

Except on the lighter land, good seed beds were difficult to obtain and tilths have been generally poor. Rain is badly needed in most areas. Good progress was made with the sowing of sugar-beet and mangolds in some districts, but generally work is less forward than usual.